PUBLIC WORKS

CITY COUNTY STATE

Interior of the Lancaster, O., Water Purification Plant

JUN 15

THE Lancaster plant, described on pages 9, 10 and 11 of this issue, is an outstanding example of the modern water purification plant. Iron removal and softening add to the attractiveness and utility of a safe and palatable water, and make it more suitable for both domestic and industrial use.

The description of the Lancaster plant is one of a group of articles in this issue which are designed to present "The Newer Developments in Water Purification." This series will be carried through succeeding issues, and will provide our readers with complete information on these newer developments and methods of purification. During the past few years, although construction has lagged, research has continued and new ideas and new methods have developed. It will be our duty to present these so that the projects of 1933 and 1934 will serve better than ever the needs of the water works field.

For in the "new deal," engineers, superintendents and officials should cooperate to make use of the most efficient developments in water treatment and in all other useful and needed public works construction. Modern design, and the use of modern equipment are vitally necessary. The standards of a few years ago, and the methods and equipment for attaining these standards, may not be best today. And in these times and those immediately ahead every dollar should be made to purchase the maximum possible efficiency.

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Sightseeing in Water Pipes

IF YOU could look into your water pipes, the things that you would see might appear quite as queer and unusual as the things Alice saw in Wonderland.

After doing service for these many quickly passing years the inside of the water pipe is no longer the clean, smooth affair we ordinarily think.

Like the natural caverns of Kentucky, deposits and incrustations, gathering through these years, have made it far different than the straight clean tube laid down originally. But water pipes are not laid for sightseeing.

Rising pumping costs—diminished water pressure—reduced hydrant flows, not admission charges, are the result.

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YES AND KERSLAKE REPORTS A SAVING OF 20 TO 50% OF CHEMICAL COSTS AT OSSINING BY PUTTING **NUCHAR** IN WITH ALUM JUST AHEAD OF THE MIXING TANK. HE RECOMMENDS USING **NUCHAR**, NOT JUST EXPERIMENTING WITH IT.

WHERE IS HUEKEBA FROM? GEORGIA SOME PLACE AND HE CLAIMS **NUCHAR** TREATMENT COST ABOUT 25¢ PER MILLION GALLONS. HE HAS HAD BETTER COAGULATION AND ALUM WAS REDUCED FROM ONE GRAIN PER GALLON TO 0.6 gpg

GAHN OF FT. PIERCE SAYS, "SINCE CARBON WAS INTRODUCED WE HAVE OBTAINED BETTER RESULTS WITH A SMALLER AMOUNT OF ALUM. THE SLUDGE DOES NOT RISE TO THE TOP OF THE WATER AND BAD ODORS ARE ABSENT."

YES I HEARD ALL THOSE FELLOWS TALKING ABOUT **NUCHAR**. IT MUST BE GOOD BUT THIS MAN PARKS FROM LINCOLNTON, N.C. EVEN GOES ON RECORD IN A LETTER SHOWING IN DETAIL A SAVING IN COST per M G OF $4.60 FOR WHICH HE GIVES **NUCHAR** CREDIT. HE SAID AFTER HE STARTED USING **NUCHAR**, A MUCH BETTER FLOC WAS OBTAINED, WITH LESS LIME AND ALUM, SLUDGE WAS STABILIZED, ALGAE GROWTH WAS RETARDED IN BASIN AND ALL TASTE AND ODOR WAS REMOVED.

Yes Sir! NUCHAR *must be good . . .*

I'm glad I came here and heard about it!

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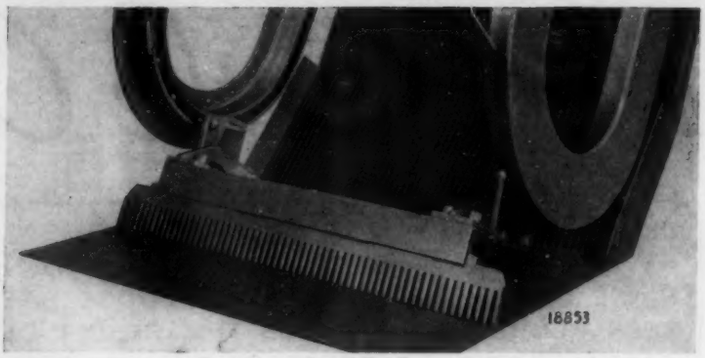

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THIS *NEW* Jeffrey Screen is different. It is provided with a special hinged scraper which prevents jamming of the mechanism from the accumulation of foreign material in the bottom of the channel or upon the screen proper.

The teeth of this special hinged scraper, acting as a comb, pass entirely through the bars of the screen, cleaning not only the surface but the space between the bars, thus eliminating grease formation.

The scraper mechanism descends in a runway somewhat removed from the screen thus entering the sewage back of or behind the accumulated refuse. Upon reaching the bottom of the channel the scraper drags horizontally for about 2 ft. before reaching the screen. At this point it ascends with the teeth projecting through the screen and, in this position, comes up under the floating refuse, carries it to the top, and discharges it into suitable receptacles.

At the discharge point the scraper engages a wiper which removes any material that may adhere to it. This wiper, being counterbalanced, returns to its normal position after the scraper passes.

The control mechanism is such that the screen may be operated continuously or at intervals of from 2 seconds to one hour. Differential float control can also be furnished if desired.

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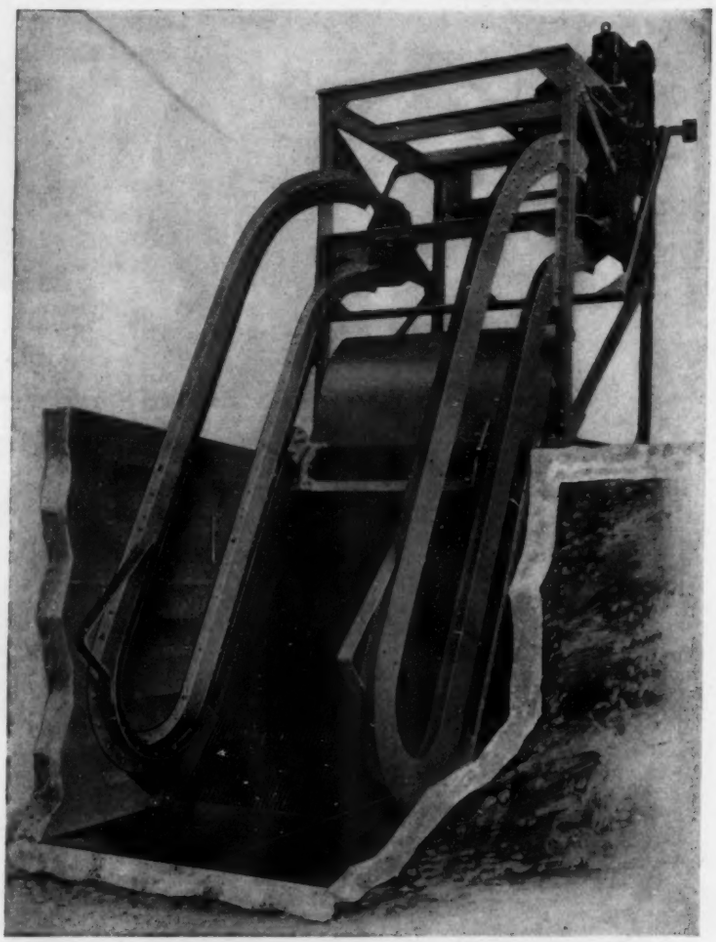

A close-up of the hinged scraper mechanism is shown in the upper right hand illustration. Note the long teeth which engage the bar screen and thoroughly clean it of all refuse as it carries it out.

The illustration directly above shows the complete unit. Note how the scraper teeth are deeply engaged in the bar screen, showing how it cleans as it carries out the refuse. Note also the counterbalanced wiper which thoroughly cleans the scraper of any material which may adhere to it.

●

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City County State

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? ? ? Brainstorms ? ? ?

By more or less common consent, acclamation, or what not, the title of this column is changed temporarily, at least, to the above. It seems especially fitting this month, because Mikey and Ikey are back with us again, after a long absence. Here they go again!

Mikey & Ikey Week-ending:

Mikey and Ikey have been spending the week-end with friends and have been separated for a few days. Mikey called up Ikey on the telephone—they were seven miles apart—and told him to start down the road, so they might meet on the way. The road was down hill for Ikey, who walked at the rate of four miles an hour; but it was all hard going for Mikey, and the best he could do was three miles an hour.

Ikey's little brother started with Ikey on his bicycle, but as it was all down hill, he highballed along at 15 miles an hour until he met Mikey, who sent him back to tell his brother to step a little faster. Uphill Izzy (the little brother) couldn't do better than 5 miles an hour, but he kept going until he met Ikey, who couldn't hurry any faster, and sent Izzy back again, this time at his former rate of 15 miles an hour. If Izzy continued pedalling back and forth, first downhill and then up, at his established rates, how far would he travel before his brother met the hot and puffing Mikey?—*Robert Newton Clark.*

Bells for Mikey & Ikey:

Mikey and Ikey went up in an airplane, struck a waterspout, and both were thrown out at the same time. Mikey fell through a vacuum in the center of the spout and struck the ocean at the same time that Ikey struck on top of a cliff. Ikey, of course, fell through the atmosphere and the raging elements.

The height of the top of the cliff above the ocean is 1600 feet, and equals numerically the square of the time of their fall in seconds. Using g=32 for gravity on Mikey, how many miles did each fall?—*Walter S. Wheeler.*

And the Solutions:

It was a long spin to get there, but the airplane mentioned last month, appears to have traveled 240 miles an hour. Quite a large number of our readers got this answer—and some didn't. Well, as we said, it was too fast to go anyway, and our sympathies are with those of our readers who arrived at a lower speed, even though they weren't mathematically correct.

And the contractor—we had practically forgotten him (and his bill)! Well his bid was $5500, and everyone got the correct answer.

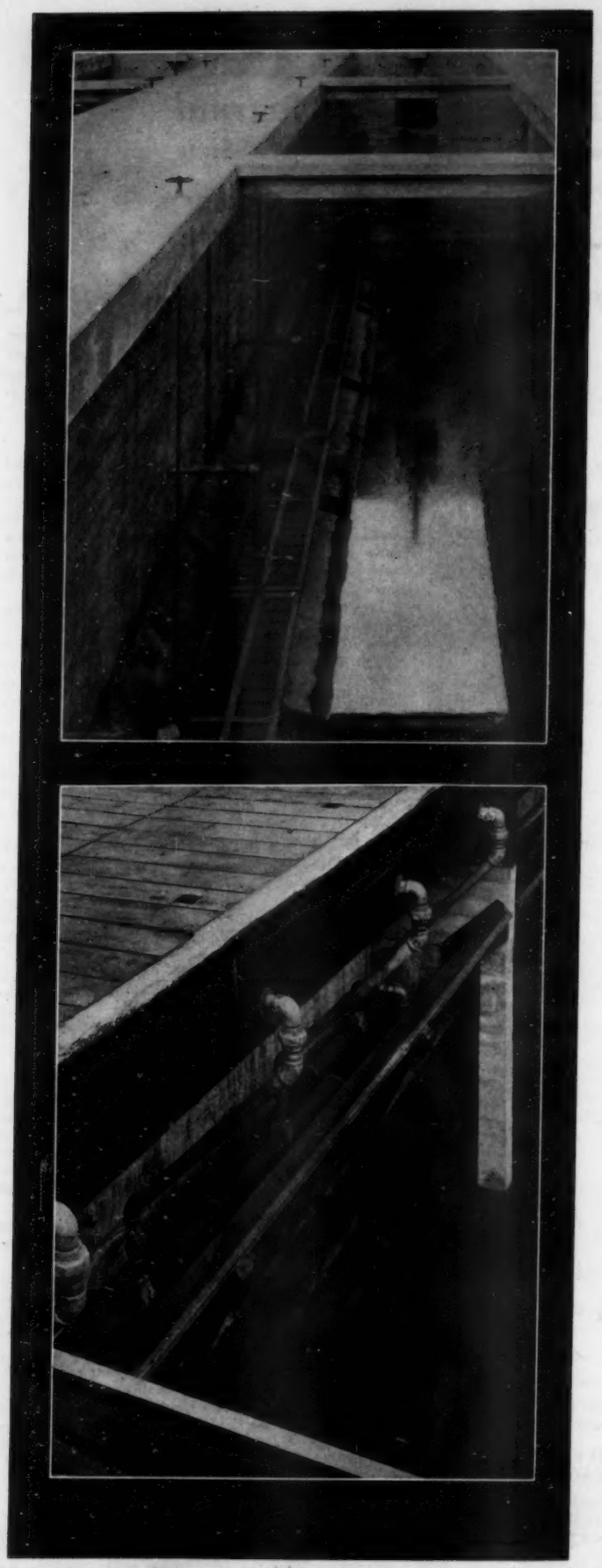
How many really figured out the answer to the pump sequel problem and got the answer right? As we see it, the effect of running one pump continuously would be to maintain the water level in the excavation at a lesser height than would prevail without pumping. Water income would equal water outgo (fine for budgets but not so good for drainage pumps) and a condition of equilibrium would be maintained. If only a better parallel could be drawn between pumps, budgets and equilibrium, we could lick any depression without further ado.

Coming:

There is a real hen and chicken, dog and hog problem contributed by George H. Overing of Nebraska, which we are saving for the July issue. It will keep you out of mischief over the 4th. To get ready for this, you might practice up on the good old cocoanut problem.

So long till next month.

BENJAMIN EISNER.



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PUBLIC WORKS

City, County and State Engineering and Construction

Vol. 64 — *June, 1933* — No. 6

Iron Removal and Zeolite Softening Plant at Lancaster, Ohio

By Charles P. Hoover

Sanitary and Water Purification Engineer, Columbus, Ohio.

THE new iron removal and zeolite softening plant at Lancaster, Ohio, has been in operation for about two and one-half months. The water supply, taken from wells, is aerated, filtered through sand filter beds, and softened by synthetic zeolite. During the month of April, when a daily average of 1,028,000 gallons was softened, the hardness was reduced from an average of 359 parts total to 76 p.p.m.; and 50% of the CO_2 and all of the iron are being removed. The cost of the plant, including two 800 g.p.m. wells, was a little less than $75,000.

Lancaster has a population of about 19,000 and is located about 30 miles southeast of Columbus, Ohio. The old plant, which has been replaced by the new one, consisted of two large air compressor units, six air-lift wells directly behind the plant, a circular suction well into which the wells discharged, and two 1,400 g.p.m. centrifugal high-service pumps taking their suction from the suction well and discharging into the mains at approximately 120 pounds pressure. There is also a storage reservoir located near the northern edge of the corporation line and several miles distant from the iron removal and water softening plant, which holds about 3 million gallons of water and will be continued in service.

The existing high-service pumps and the air compressor units were in excellent condition and of ample capacity for present requirements, and, as it was necessary to maintain uninterrupted service during the period of construction, they were left in their old location and the new plant constructed around them without disturbing their foundations or discharge piping. The efficiency of the air lift equipment was only about 18%, so it was decided to keep the six air lift wells and the air compressor units for reserve and two new 8-inch deep wells were drilled and equipped with 800 g.p.m. vertical turbine pumps. The new plant has a present capacity of two million gallons per 24 hours. An extra sand filter, not equipped, and an extra softening unit, not equipped, have been installed. When they are equipped the plant will have a capacity of three million gallons daily.

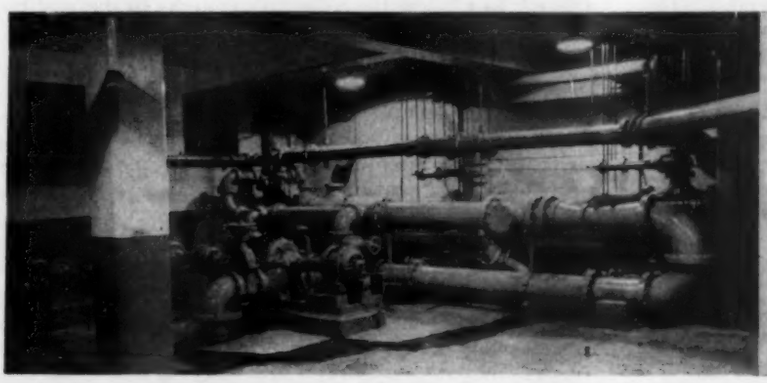
Zeolite rather than lime and soda-ash was selected for softening because there was no suitable place to discharge the sludge that would be produced by the lime-soda-ash process.

The raw water supply shows the following analysis:

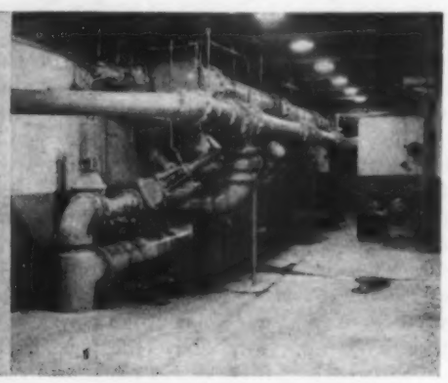
Free carbon dioxide	34	to	55	parts per million
Iron	2.4	to	3.4	" " "
Average alkalinity	309			" " "
Average total hardness	359			" " "

New Plant and Operating Procedure

Aer-O-Mix and Retention Basin. The wells discharge through a 14-inch main to the inlet of an Aer-O-Mix, located on the top of the reaction or retention basin, which has a holding time of approximately 30 minutes when the plant is operated at its rated capacity of 1400 gallons per minute. The U tube of the Aer-O-Mix extends down into the basin, and its discharge is just above the top slab of the basin. The top of the basin is walled, and the water from the Aer-O-Mix collected on it is discharged through a vertical pipe extending to within 36 inches of the basin floor. A concrete baffle wall is provided through the center of the basin, and



Transfer pumps, wash water pumps and piping for zeolite softeners



Pipe gallery of sand filters

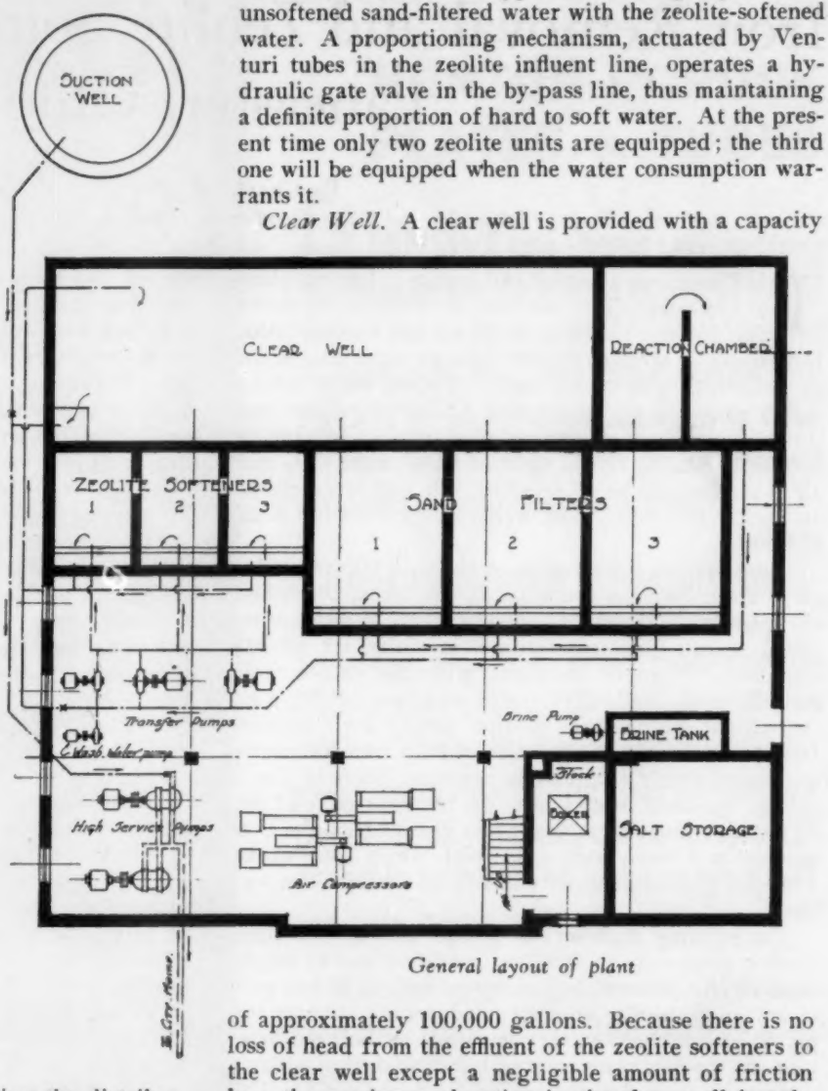
the water must pass from the bottom of the drop pipe around the end of the baffle wall to reach the outlet, which is located near the top at a point farthest from the inlet. A float switch in the basin controls the deep-well pumps, restricting the maximum variation in water level to three feet. In the passage of the raw water through the Aer-O-Mix and the reaction basin, 50% of the CO_2 is removed and all of the iron is oxidized and sufficiently precipitated so that it is entirely removed by filtration through the sand filters. Because of the fairly high velocity of the water through the basin and the colloidal nature of the precipitate formed, there is little or no settling in this basin. No sludge blowoffs were provided. A 6-inch valved drain line is provided which connects with the waste header leaving the plant.

Sand Filters. The water from the reaction basin flows by gravity to the sand filter units, which are of conventional construction, but the walls have been carried 34 inches above the level of the operating floor to provide allowance for the variation in water level, which follows that in the reaction basin. Each filter is provided with: A five-valve hydraulic operating table equipped with an indicating rate-of-flow and loss-of-head gauge, three steel wash troughs, an effluent rate-of-flow controller, and Wagner underdrains consisting of rectangular cast iron headers with drilled laterals on 12-inch centers, and pre-cast slotted concrete blocks placed between the laterals. The filter beds are of conventional sizes of sand and gravel. Two filter units are equipped at the present time, with a third one ready to be equipped when necessary.

Zeolite Softening Units. The effluent lines of the sand filters enter a common header, from which the suctions of the transfer pumps are taken. These pumps discharge into a common header which supplies water to the three zeolite softening units. A rate-of-flow controller is provided in the inlet line entering the distribution system in the bottom of each softening unit. The distribution consists of cast iron headers with drilled laterals on 6-inch centers, into which are fitted, on six-inch centers, malleable iron strainers with long shanks and flat baffled tops. The whole distribution system is grouted in completely so that only the strainer heads extend above the concrete. The strainers are covered with four layers of graded gravel 12 inches deep, which supports a layer of Crystalite (a manufactured gel type zeolite) 54 inches deep. Each zeolite unit has inside dimensions of 9 ft. x 11 ft. and contains 450 cubic feet of zeolite. A freeboard of 27 inches is left above the surface of the zeolite bed, and two steel collecting troughs are provided above the freeboard level. These troughs are similar in construction to the filter wash troughs and their top edges are very carefully leveled so that the softened water flowing up through the beds is evenly collected. The zeolite units are provided with a forebay similar to that used with sand gravity filters. Softened water flows from the collecting troughs through the forebay into a softened water effluent header.

Each zeolite softener is provided with: A five-valve operating table, on which is mounted a recording and indicating rate-of-flow gauge showing the flow through the unit; a hard water bypass for mixing a portion of unsoftened sand-filtered water with the zeolite-softened water. A proportioning mechanism, actuated by Venturi tubes in the zeolite influent line, operates a hydraulic gate valve in the by-pass line, thus maintaining a definite proportion of hard to soft water. At the present time only two zeolite units are equipped; the third one will be equipped when the water consumption warrants it.

Clear Well. A clear well is provided with a capacity



General layout of plant

of approximately 100,000 gallons. Because there is no loss of head from the effluent of the zeolite softeners to the clear well except a negligible amount of friction loss, the maximum elevation in the clear well is only about 1 foot below the collecting troughs in the zeolite units. Thus the head developed in the transfer pumps in putting the water upward through the zeolite units is not wasted, but is maintained as a positive head on the high-lift pump suction line. This line was laid so that valved connections are maintained to both the new clear well and the old suction well. The clear well is provided with a float-operated depth gauge.

Wash Water Tank. A steel elevated wash water tank with a capacity of 40,000 gallons was erected north of the building. The wash water line runs along the front of the filter and zeolite units, and serves for both filter wash and regeneration of the zeolite softeners. A 250-g.p.m. pump is provided for filling this tank with sand-

Exterior view of Lancaster Purification Plant

filtered unsoftened water. This pump takes its suction from the sand filter effluent header, and is controlled by an altitude switch, making its operation entirely automatic.

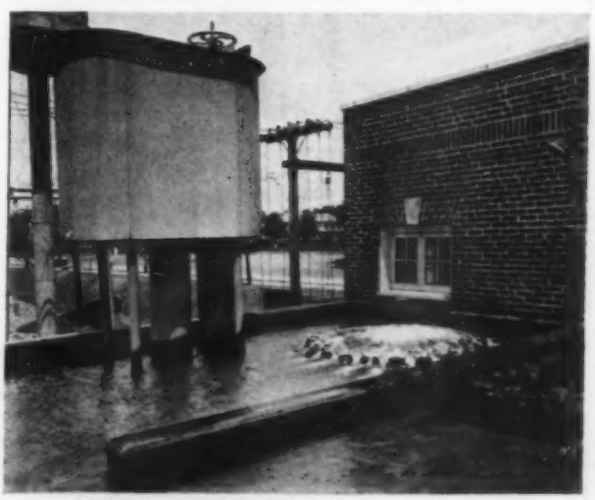
Salt Storage Basin. The salt storage basin is of concrete construction with its floor at approximately the level of the pipe gallery floor. Its inside dimensions are such that it has ample capacity for one and one-half carloads of salt. The top slab is provided with four standard-size manholes for convenient filling. The bottom of the storage basin is sloped to a rectangular trough which is covered with half sections of drainage tile. A layer of gravel is placed in the bottom with a depth of 12 inches above the trough. A brine measuring tank (concrete construction) seven feet deep is located in the pipe gallery. A valved connection is provided from the end of the trough in the salt storage basin to the bottom of the brine-measuring tank. Valved lines also extend from the wash-water header in the pipe gallery to the top of the salt storage basin and the bottom of the brine measuring tank. All valves are hydraulically operated from a three-valve table located on the operating floor directly above the measuring tank. A double float-operated depth gauge is mounted on this table, showing the depth of water in the storage basin and the measuring tank. The storage basin is carried full of water at all times, and the amount of brine necessary for the regeneration of one softener unit is drawn into the measuring tank at one time. This brine is diluted to approximately 12° Baume by adding sand filtered unsoftened water from the wash-water header, all measurements being taken from the measuring tank depth gauge.

Regeneration of Softener. A centrifugal pump is provided in the pipe gallery which takes its suction from the brine measuring tank, and discharges through a brine header to the surface of the zeolite units. This pump is started by push button switches, mounted on the end of each zeolite operating table, and stopped automatically by a float switch in the measuring tank when the proper quantity of brine has been delivered to the softening unit. The brine enters the freeboard above the zeolite through a distribution system consisting of crossed pipes, with the ends at the corners of the zeolite basins, which are drilled along one side a little below horizontal with a row of holes, which causes the brine to be introduced with a rotary motion as a layer above the zeolite beds. After the brine has been introduced, water is drawn into the basin in the space above the beds, and allowed to flow downward through the zeolite at a slow rate. The waste water is collected in the collecting system at the bottom of the unit and flows out through a waste header under the pipe gallery floor. This header is provided with a Venturi tube and gauge mounted on a table at the end of the zeolite operating floor, the gauge indicating the rate of flow during each step of the regeneration. This table is also provided with vacuum sampling devices for obtaining samples from the bottom of the units during regeneration and from the top during the softening runs. The walls of the zeolite softening basins have been carried up to the same height as the sand filter walls, so that it is possible to draw enough water into them at one time for the entire washing operation. Marks have been provided on the basin walls showing the amounts of water needed for each operation. There are two rates employed; during the first rate the brine is passed slowly through the zeolite, and during the second rate, wash water is passed through rapidly to wash out the last traces of brine after it has completed its work. Each zeolite softening unit is out of service about one hour for regeneration between softening runs.

Results of Operation. The results obtained so far have been very satisfactory. The zeolite runs have averaged 8.4 hours each in duration, the zeolite removing approximately 20 grains of hardness per gallon from 300,000 gallons of water per regeneration. The zeolite has shown a capacity of a little more than 12,000 grains per cubic foot. The salt consumption has been approximately 1/3 pound per thousand grains of hardness removed, and the water (sand filtered unsoftened water) required for regeneration has averaged about 3.9 percent of the total pumpage. We believe that these are the lowest averages that have been obtained at any municipal softening plant. The salt cost of the zeolite treatment has been about 2¼ cents per thousand gallons. The average hardness was reduced from 359 to 76 parts per million, as already stated, during the month of April. The delivered water has also been iron free. The percentage of wash water for the sand filters has been high, about 4.7 percent. Scraping the fines from the surface of the sand filters is expected to lower future wash water requirements.

Personnel. The preliminary investigations, the preparation of detailed plans and specifications, the supervision of construction and starting up of the plant were under the direction of the author. Henry Eiselt, associate engineer and architect, Columbus, prepared the plans. Joe Smart, engineer, Columbus, and Walter W. Graf, city engineer of Lancaster, had direct charge of

(Continued on page 18)



The Aero-Mix header tank and splash plate

Water Purification Studies

Introducing Some Final Reports by H. W. Streeter on U. S. Public Health Service Investigations

SEVERAL articles have appeared in PUBLIC WORKS from time to time giving abstracts and résumés of reports published at intervals during the past six years by the U. S. Public Health Service, containing results of investigations, made by its engineers and other scientists, of the efficiencies of sedimentation, filtration and chlorination and the possibilities of improving the procedures of using them, their limitations, etc. These have been written by H. W. Streeter, sanitary engineer in the service, and published in Public Health Bulletins Nos. 172, 193, 737, 987, 1114, 1170, 1392 and 1434; and a résumé was given in the P. H. Report for April 14th, 1933.

These several hundred pages give a wealth of data in detail, with tables, diagrams, charts, etc., which have been of great value to students of the subject. Even this voluminous matter, however, has not exhausted the information furnished by these investigations, several phases of which have barely been touched upon. A number of leading water works engineers have expressed a wish that this additional matter might be made available, and at our request Mr. Streeter has consented to present these data and conclusions in a series of articles, to appear in PUBLIC WORKS beginning with the July issue.

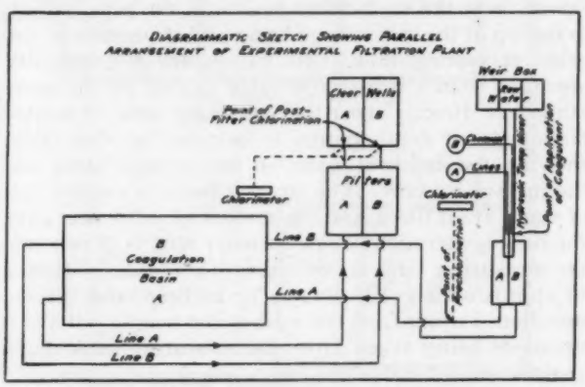
As a preparation for these, it seems desirable to give a brief statement concerning the investigations and the results previously published, to refresh the memories of those who have already read them, and for the information of those who have not done so. It should be understood that the article herewith is the barest outline of the investigation procedure and the conclusions derived therefrom.

The Investigations

These investigations have dealt with bacterial efficiencies only; other qualities were considered only as they might be incidental to this.

The first studies were made at the Cincinnati and Louisville plants. Later, ten municipal plants taking water from the Ohio river, fourteen treating water from the Great Lakes, and seven at other localities were studied. Meantime, an experimental plant had been put into operation at Cincinnati "to provide a means whereby a detailed study could be made of the limits of raw water pollution which are consistent with the production of effluents conforming to accepted standards of bacterial quality, having reference to water purification plants found along the Ohio river" and similar river systems. In this plant, river water was used, the pollution of which could be increased as desired by mixing sewage with it in predetermined proportions.

Realizing that there might be some question as to the applicability of results obtained at the experimental plant to other plants under actual operating conditions, especial attention was paid to this point. It was found that "the over-all bacterial efficiency of the experimental plant, both with and without the aid of chlorination, agrees very closely with the corresponding average efficiency of the five Ohio river municipal plants having the same degree of elaboration as regards the treat-



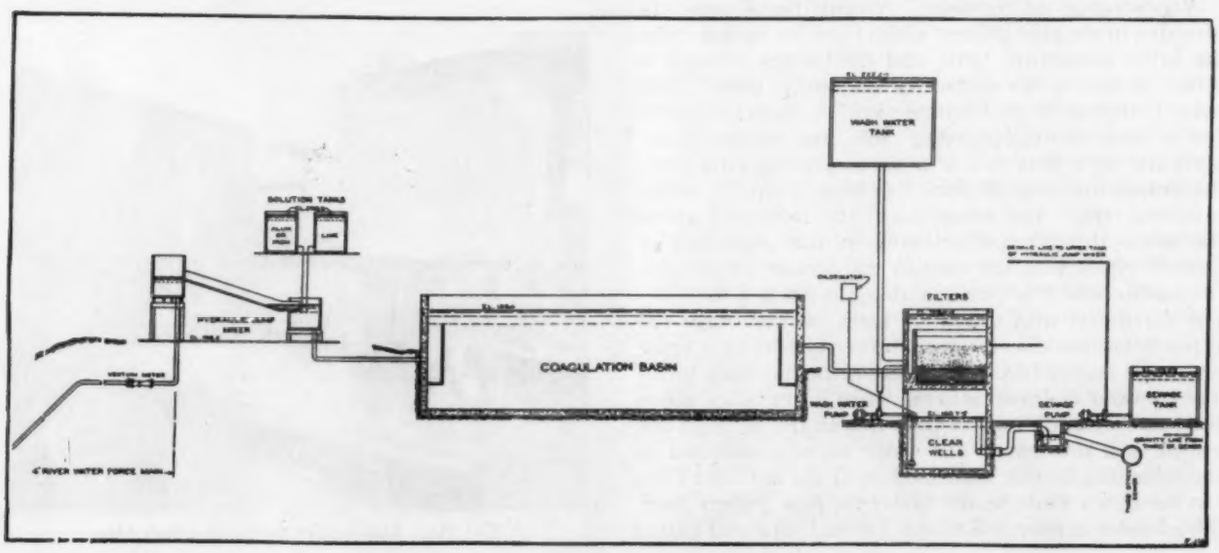


Fig. 1.—Diagrammatic profile of experimental filtration plant. Above—Diagrammatic sketch of plant.

ment given the water and under similar conditions of raw water pollution," and the results obtained from the plant "should be capable of application to normal conditions of full-scale operation without any substantial modification."

A few angles of the studies covered in the detailed reports were not included in P. H. Report of April 14, and brief summaries are presented below of two of these which seem to be of considerable interest.

Effect of Temperature and Turbidity on Efficiency

Studies made of the effects of variations in temperature and turbidity on efficiency of purification, based on the operation of the experimental plant, resulted in the following general conclusions:

Temperature—"The over-all efficiency of bacterial removal, including chlorination, as regards both the plate growers and the B. Coli, appears to be relatively little affected by seasonal changes, this being especially true of the B. Coli."

However, as measured by 37° counts, the efficiency of filtration is apparently higher in winter than in summer, and that of chlorination higher in summer than in winter; the B. Coli being less affected by the seasonal changes than are the 37° counts.*

Turbidity—The over-all efficiency of removal of 37° bacteria is influenced decidedly by variations in raw water turbidity; chiefly, however, because of the greater efficiency of preliminary coagulation-sedimentation with increased turbidity. In fact, this is the only phase of the treatment which is affected in any consistent manner by variations in turbidity. "Efficiency of B. Coli removal does not appear to be influenced in any consistent direction or to any material extent at any stage of treatment by variations in raw water turbidity."

The fact that B. Coli removal is affected little by temperature changes, and not at all consistently or measurably by turbidity, is of basic importance, owing to the sanitary significance of this group of bacteria.

Frequency Variations in Qualities of Raw Waters and Effluents

Data from the ten Ohio river plants were studied to learn if there was any way of foretelling how great departures from a mean bacterial count of raw water or of plant effluent might be expected, and how often to expect temporary lapses of given amounts below such mean. The data showed that there was a general relationship between the yearly mean and the frequency with which the counts equalled or exceeded various amounts, the latter increasing as the mean count for the plant in question increased. That is, should the mean pollution of the river increase, the lapses below a given count would increase in frequency; the relation being expressed as a logarithmic equation.

The average relations for the ten plants between the mean B. Coli index of the raw water and the frequencies with which the index equaled or exceeded certain designated limits are shown in the accompanying curves; while another set shows the corresponding relations to the B. Coli index of the effluent.

* In the first studies, the 20° bacteria were recorded and on the basis of these the results were exactly the reverse—the filter efficiency was higher in summer than in winter. This is thought by Mr. Streeter probably to be due to the fact that 37° growers do not survive the colder water temperatures as well as do the 20° growers, hence are removed more readily under winter conditions by sedimentation and filtration than are the latter. The same marked difference in the behavior of these two groups of bacteria has been noted in natural streams. As the 37° growers in these experiments represented the sewage bacteria, they were given chief consideration.

The use of these curves and of another set showing the relations between the B. Coli index of a raw water and the corresponding index of treatment effluents (Fig. 4) is illustrated as follows:

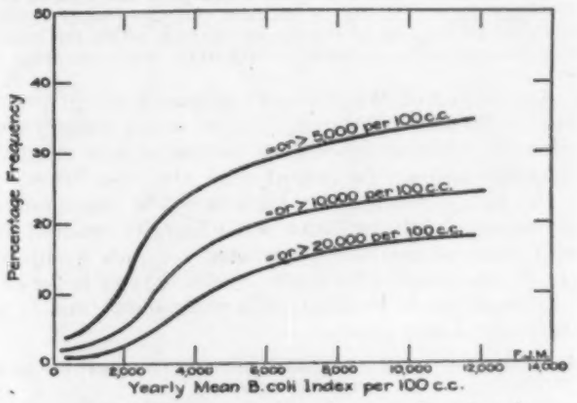


Fig. 2.—Relation between the yearly mean B. coli index, as observed in the raw waters of the 10 Ohio River plants, and the estimated frequencies with which the index equaled or exceeded designated limits.

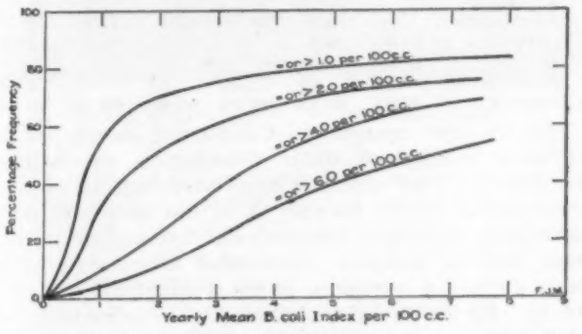


Fig. 3.—Relation between the yearly mean B. coli index, as observed in the effluents from the 10 Ohio River plants, and the estimated frequencies with which the index equaled or exceeded various designated limits.

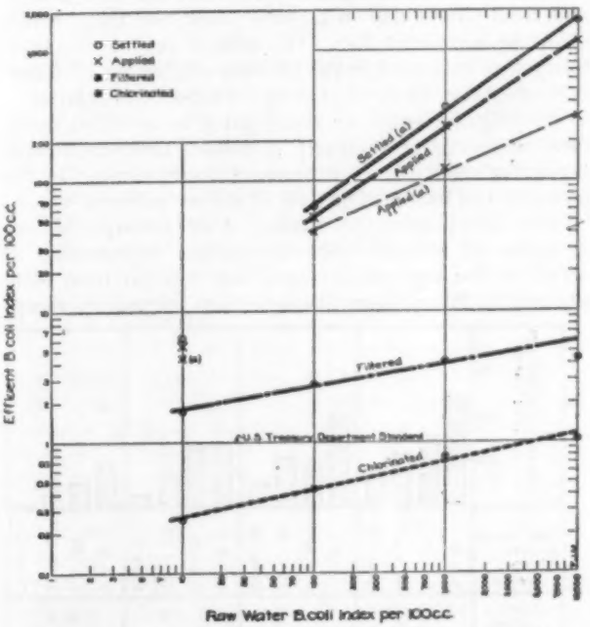


Fig. 4.—Relations between B. coli index of raw water and corresponding index of effluents from successive stages of treatment, as derived from combined data from the 10 Ohio River plants.

Assume a raw water with a yearly mean B. Coli index of 2,500 per 100 cc, to estimate the effect of an increase of this to 5,000 on the frequency with which the B. Coli index of the chlorinated filter effluent would exceed the Treasury Dept. standard of 1 per 100 cc. Fig. 4 indicates that this change in the raw water would produce a change in the effluent index from 0.8 to 1.0. Fig. 3 indicates that this change would result in an increase of the frequency with which the index would exceed one, from 48% to 54% of the year's samples.

An abstract of Mr. Streeter's summary was given in PUBLIC WORKS for March, 1933, to which readers are referred. Several interesting determinations omitted from that abstract for lack of space are given below.

Percentage removal of bacteria.—The comparative percentages of the total raw water bacteria removed by each stage of treatment, averaged for each group of plants, are given in the table. Series A refer to the experimental plant, B to the Ohio river plants, and C to the Great Lakes plants.

Percentage of total raw-water bacteria removed by each stage of treatment

	24-hours, 37° C.,			B. coli index		
	Series A	Series B	Series C	Series A	Series B	Series C
Stage of treatment						
Coagulation-sedimentation	72.9	82.6	59.0	60.1	77.5	62.7
Filtration ...	25.9	16.6	27.2	39.78	22.42	32.50
Post-chlorination	1.14	.68	12.36	.10	.07	4.24
Combined ..	99.94	99.88	98.56	99.98	99.99	99.44

Excess lime treatment.—Considered merely as a chemical method of water disinfection, excess-lime treatment did not appear to be as advantageous as prechlorination, chiefly because of its less consistent performance, the longer time required to complete its action, and the difficulty experienced in maintaining a high degree of constancy in the residual pH or causticity. Its use should be followed by recarbonation, so that it may not cause after-deposits in mains and house fixtures.

Variations in efficiencies.—Each stage of treatment showed variations in efficiency between different plants, and from day to day in a given plant, not all of which could be accounted for. The widest degree of variability was indicated in the relative efficiencies of filtration; the least, in those of coagulation-sedimentation.

Prolonged storage of water prior to artificial treatment appeared very clearly to possess inherent advantages for effecting a preliminary improvement in the physical and bacterial quality of highly polluted waters. "The possibilities of this method, either through the construction of storage reservoirs or the impounding of water in flowing streams, have not thus far been fully utilized in this country, though they are widely recognized in certain European countries, notably in England, where storage is practiced extensively in connection with artificial water treatment. Although the difficulty and expense involved in providing long storage of water doubtless would be great in many instances, particularly in the level sections of the Middle West, its feasibility has been demonstrated even under such relatively unfavorable circumstances. It will be used more generally in the future than in the past, as its great advantages become more fully appreciated."

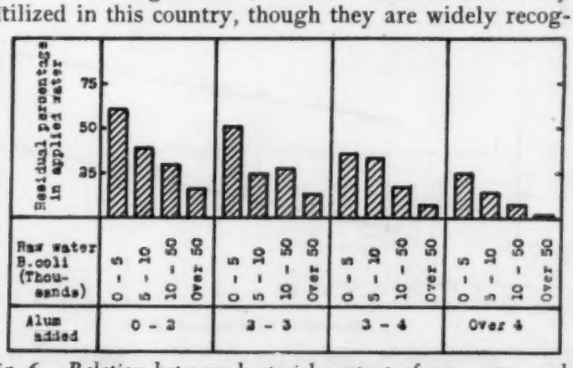


Fig. 6.—Relation between bacterial content of raw water and bacterial efficiency of coagulation-sedimentation, as observed within various ranges of alum added to raw water.

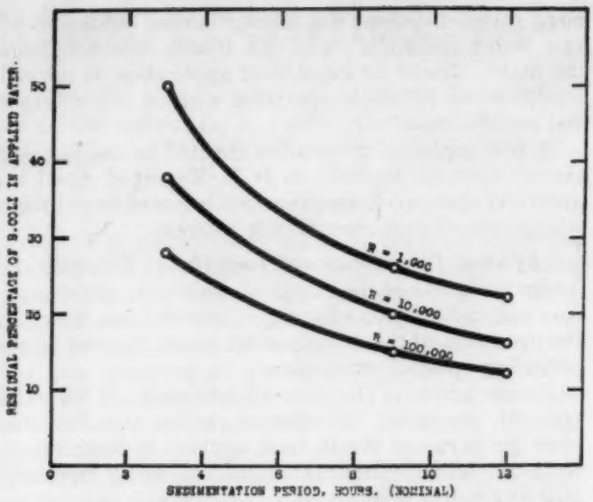
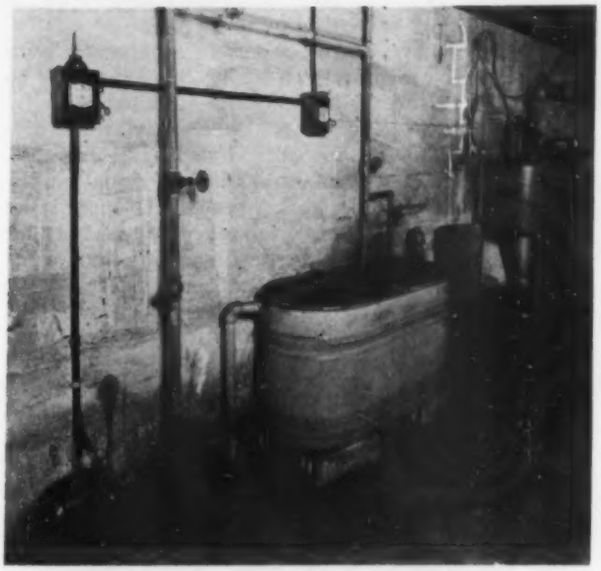


Fig. 5.—Relation between period of sedimentation and residual percentages of raw water B. coli in applied water, corresponding to indicated numbers of raw water B. coli. R signifies raw water B. coli index per 100 cc.

Varying amounts of coagulant.—The general effect of increasing densities of coagulant or bacterial efficiency was discernible, not only after sedimentation but also after filtration and, to a less extent, even after final chlorination of the filtered effluent. A measurable improvement in efficiency was obtainable through the entire treatment process by increasing the amount of alum up to densities ranging as high as 4 to 5 grains per gallon, and the general trend of the residuals would suggest that fairly substantial gains in efficiency might be expected with even higher amounts. This was found to hold irrespective of the raw water turbidity or bacterial content, though it was more apparent when the turbidity and bacterial numbers were higher.

Limitations of purification.—Although theoretically it may be possible to deal successfully with the most highly polluted water by a sufficiently elaborated combination of processes, the practical difficulties encountered in routine large-scale purification operations were exemplified by the plants studied by the Bureau. In no instance was there conclusive evidence that these plants could produce effluents of satisfactory potability and sanitary quality from raw waters of unlimited degree of pollution. The investigation "pointed clearly to the operation of a law of diminishing returns in the efficiency of multiplied processes of water purification. Although such multiplication appears to assure increased stability of performance in dealing with raw waters of highly variable quality, it exacts penalty in a diminished efficiency of certain individual stages of treatment. These limitations should be taken into account in estimating the net advantages to be gained through elaborations involving multiple-stage treatment."

Latest Procedures In the Use of Activated Carbon



Feeding activated carbon at St. Cloud, Minn.

IT IS about four years since George R. Spalding at the New Milford, N. J., plant of the Hackensack Water Co. made the first use of powdered activated carbon for the purpose of removing tastes from water. Since then, this use has been adopted for approximately five hundred public water supplies. Meantime, details of procedure have been developed by trial along different lines, and much has been learned concerning the place of application, amount of dose, and combination with other phases of the treatment which will give the best results under different conditions; but much remains to be learned and confirmed by future investigations by technically qualified and unprejudiced experts.

There is now no question as to the efficiency of this material in removing odors and in stabilizing sludge; and apparently none as to its effect in improving coagulation, to judge by the number of water departments reporting such effects. Reduction by it of free alum in the filter effluent is reported by Smith and Baldwin at Richmond, Va., R. T. Mills at Southern Pines, N. C., and others; and it apparently reduces the amount of coagulant required for optimum results.

Applying At Point of Coagulant Application

Filter Clogging—The first user of powdered activated carbon applied it to the filter influent. At least two of these pioneers—Spalding and Poarch—and several other users found that the carbon was carried over onto the filter and shortened the filter runs, and changed the point of application to that of the coagulant. Fitzgerald, of Norfolk, Va., was the first to apply carbon in the coagulation process solely for the purpose of seeing whether tastes and odors could be controlled without shortening filter runs. The water there is from shallow lakes and contains high amounts of algae during the troublesome months, with resulting tastes and odors; but these were removed satisfactorily with an average of 2 p.p.m. of carbon so applied. Abundant experiences since then have demonstrated that if the carbon be applied in the coagulation process there need be no shortening of filter runs; in fact, the runs are sometimes lengthened, presumably because of the improved coagulation obtained by its use.

Stabilizing Sludge—In a number of plants the alum sludge which settles in the sedimentation basins putrifies and is very offensive when removed; moreover, the gases of putrefaction absorbed by the water flowing through the tank above it contribute offensive tastes to it. This was the case at Toledo, O., and R. W. Furman, chief chemist of that purification plant, was the first to apply carbon in the coagulation process for the stabilization of the sludge and its effect on taste and odor. This effect was demonstrated there, and later in a number of other plants, and is one of the most valuable results obtained from the use of this material.

When the carbon is applied together with coagulant, it is necessary to use more carbon to obtain taste and odor control. This might seem like a waste of material, but the benefits obtained incident to its application at this point warrant its use. Among these benefits, in addition to those just named, are the improvement of coagulation and the reduction possible in the amounts of coagulant and of chlorine required.

Effect on Coagulation—The last point is one of the results indicated by experiments being conducted by W. S. Russell at Salem, Va. He has built to scale a glass coagulation basin to permit the observation of floc formation and the path followed during settling. He has experienced with ferrous sulphate, ferric chloride and alum as coagulants, and finds that the addition of activated carbon to either of them materially assists floc formation and reduces by about 25% the amount of coagulant required.

S. D. Poarch, superintendent of the Olean, N. Y., water works, reported last fall that applying Nuchar to the coagulated water "reduced the amount of alum necessary for good coagulation" and also that of chlorine desirable in prechlorination. Experiments conducted at Fort Pierce, Fla., in which carbon was mixed with alum and fed with a single dry feed machine, indicated that carbon assisted floc formation and reduced the amount of coagulant desirable.

It seems to be demonstrated that small amounts of powdered carbon used with the coagulant are more beneficial toward floc formation than large amounts. L. L. Hedgepeth (of the Pennsylvania Salt Co.) recently reported that 2 parts per million produced a more stable floc in Elizabeth, N. C., water than 4 p.p.m.

Several plants seem to have demonstrated that a mixture of lime with the carbon, say one lime to 15 carbon, slightly hastens sedimentation; which is especially advantageous where there are no filters. Several Texas cities have adopted this procedure.

Suggested Procedures

Although many of the reported experiences with this material corroborate each other, others appear to be contradictory; and while some investigators swear by one procedure in its use, others are equally ardent proponents of a different procedure. This is to be expected, however, because every plant has its individual peculiarities, as have also the waters treated. As experiences accumulate and are studied, however, the reasons for these apparent inconsistencies are becoming known and it is becoming more nearly possible to determine the optimum procedure to meet any given conditions and to predict the results obtainable. Utilizing his broad knowledge of conditions and results throughout the country, F. E. Stuart, of the water purification division of the Industrial Chemical Sales Co., has, within the past month, prepared for us the following suggestions.

"Summarizing the results from observers in the field, it is now found desirable, in the case of *severe* tastes and odors, to seed the filters with powdered activated carbon by making an aqueous suspension of carbon and water and applying to the filter after washing. This seeding accomplishes that which it takes several days for carbon to do in the coagulation process. It is then advisable to blanket the sludge by applying carbon to the mixing chambers in dosages of 25 lbs. p.m.g. every 30 minutes; i. e. to say, that 25 lb. dosages per million gallons of filter capacity or pumping should be applied. A 4,000,000 gallon plant would require 25 lbs. of carbon every 30 minutes until 100 lbs. had been added. This excess carbon dosage will settle on top of the sludge and stabilize the already putrefying sludge. It is then advisable to apply carbon in the coagulation process in dosages of approximately 2 p.p.m. continuously until the taste and odor have been removed or at least relieved. A combination with prechlorination is often more beneficial than straight activated carbon alone, and often the reverse is true. However, it is interesting to note that, with the [illegible] control measures we now have at hand, [illegible] control most tastes and odors by va[illegible] procedures between ammonia-chlorine, a super[illegible] and activated carbon treatment.

"Excess dosages of carbon are some[illegible]ecessary for immediate taste control, dosage varying from 2 p.p.m. to 4 p.p.m. sometimes being recommended. With the disappearance of taste-producing conditions, it has been ordinary practice to discontinue the use of carbon; but the continuous application of 0.5 p.p.m. to the coagulation process will keep the coagulated matter stable and lengthen the time between basin cleanings, and is becoming general practice in many plants. For it is much easier to overcome a taste in a carbon-impregnated treatment plant than in a plant which has putrefying material in the coagulation basins. A plant that is equipped to feed 0.5 p.p.m. (4 lbs. per million gals.) of carbon continuously in the coagulation process can, when and if tastes and odors penetrate the basin, raise the dosage sufficiently to take care of it in most instances, which dosage will be less and the result obtained more promptly, if continuous light carbon treatment has been practiced."

Removing Manganese from Water

THE presence of manganese in water supplies was not given much attention in this country until five or ten years ago, and general recognition of it as an important problem began even more recently. It was gradually realized that it interferes with correct interpretations of the orthotolidine tests, causes stains on wash basins and laundried garments and "black water" and deposits in water pipes and meters, sometimes quite serious; it forms deposits on concrete pipes and channels, and in some cases on filter sand.

It is generally associated with iron, and is believed to be derived from the same source—dissolved from iron ore by acids. These acids may be sulphuric acid from coal mines, carbonic acid or organic acids caused by bacteriological decomposition in swamps or the bottoms of deep reservoirs.

It can be removed in the same way as iron, by changing it to an insoluble form by oxidation and precipitating or filtering it out. According to Weston "Most natural waters containing manganese have too low a pH value for the rapid oxidation of the manganese. . . . As long as the pH value of the water is low, manganese will oxidize and precipitate but slowly, but contact with highly alkaline concrete surfaces, or with manganese bacteria lining the inside of pipe works, will result in precipitation, with subsequent 'black water.'"

In general, manganese remains in solution while the pH of the water is below 8. If it is raised to 9.2 or above, the manganese precipitates, and this fact is utilized for removing it in treatment plants. Where water is softened by the lime process, producing a pH of more than 9.0, the manganese can be removed by sufficiently prolonged sedimentation or by filtration. In Baltimore, manganese is entirely removed by iron coagulation at a pH of 9.0.

Because of the high pH value necessary for removing manganese by oxidation, the use of aluminum sulphate as a coagulant would necessitate the addition of considerable lime. For this reason, iron-lime coagulation is usually employed for purifying soft water when manganese is present. Hard water high in iron is easily demanganized, especially if softened by the lime process. In Providence, manganese is completely removed from a soft, colored water by copperas and iron, maintaining a pH of about 10. However, it produces more color, hardness and iron in the effluent than did the alum treatment, but not seriously so.

At both Providence and Wanaque, where manganese is removed by adding lime, water is drawn from the bottom of the reservoir; which furnishes cooler water containing considerable iron (thus reducing the amount of iron to be added), and which is free from algae tastes; and this practice reduces the amount of iron and manganese carried to the surface when the reservoir "turns over."

Both Craig at Providence and Hopkins at Baltimore have reported recently that ferric coagulants are to be preferred to ferrous ones in the iron-lime treatment. At Providence, the granular copperas caked in the bins and tended to introduce dosing irregularities with dry feed equipment. Hopkins reports that the ferric salts

can be used with a shorter mixing period or a lower rate, and it is not necessary to allow a contact period before adding lime. Craig reported that ferric iron required less alkali for coagulation, coagulating at a lower pH.

At Providence, where alum coagulation had been used previously, it was found that proper removal of iron floc in filter washing required a flow of wash water sufficient to produce a somewhat greater expansion than had been necessary with alum.

Several plants where manganese deposits on the filter sand have given trouble have remedied this by introducing air-washing of the filters, which eliminated formation of sand cracks.

Brainerd, Minn., in 1931 put into operation a plant designed for removal of manganese (which had clogged service lines and meters) without the use of chemicals; this being, it is believed, the first plant designed specifically for this purpose. The water is forced upward through finely ground pyrolusite (containing about 70% manganese dioxide), then is sprayed onto a bed of small-size coke, where manganous hydroxide formed by catalysis is, in the presence of excess air, converted to stable manganic hydroxide and manganese dioxide in a finely divided condition. These coke beds collect 80% of the iron and manganese contained in the raw water. The manganese collected here acts as an additional catalyzer. The coke bed effluent passes through a sand filter, composed of fine silica sand on a layer of crushed basic rock, which removes the iron and such manganese as escapes the coke bed. The pH of the effluent rarely exceeds 7.3. Backwashing once in four or five weeks is performed as a precaution rather than a necessity. No chemicals are used in the plant.

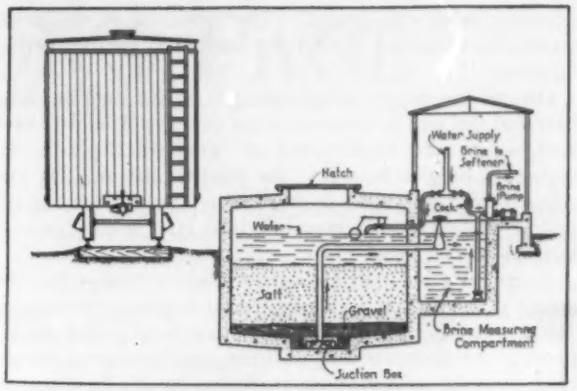
Present Status of Water Softening

JUST how many municipal supplies in this country are softened is not known, as the number is constantly increasing, but it is believed to be between 150 and 200. It is not necessary to enumerate the advantages of soft water; but a recent investigation of financial saving to consumers due to saving in soap alone is interesting. Profs. Hudson and Buswell investigated actual retail soap sales in several cities using waters of different hardness: Superior, Wis., hardness 45 p.p.m.; Bloomington, Ill., hardness 70 p.p.m.; Champaign-Urbana, Ill., hardness 298 p.p.m.; Chicago Heights, Ill., hardness 555 p.p.m. The retail soap sales in these cities per capita per year were $3.60, $4.20, $5.58, and $7.27 respectively. Using the $3.60 as a base, the additional 25 p.p.m. cost Bloomington 60 cts.; additional 253 parts cost Champaign-Urbana $1.98; and 510 parts cost Chicago Heights $3.67 per capita.

There are two general methods of softening water—lime (generally with soda ash), and the zeolite process. The former is the one originally used and still in most common use; but about 30 municipal zeolite plants have been installed, most of them during the past five years.

Lime Softening

Most lime softening plants are of the continuous type, although the earlier ones were intermittent in opration. The former are less expensive to construct, and



Wet salt storage for zeolite plant

difficulties of operation have been quite generally solved, partly by more adequate facilities for measuring and applying the chemicals properly proportioned to the amount and hardness of the water.

A typical modern lime-soda ash treatment consists of aeration and pre-mixing with lime, sodium aluminate and soda ash; coagulation in mechanical mixers; clarification in a sedimentation tank; primary carbonation, sufficient carbon dioxide being applied to remove practically all of the caustic alkalinity; clarification; secondary carbonation, sufficient carbon dioxide being applied to bring the water to a pH of between 8.3 and 9.4; filtration through sand filters.

If the carbonation is carried to a pH of 8.4 to 8.6, there will be little or no incrustation of the filter sand; but most operators do not carry it below 9.2 to 9.4, at which point the calcium carbonate is least soluble and can be removed by filtration, thus giving lower alkalinities than would otherwise be possible. This, however, causes some incrustation on the sand—a problem which is being studied. According to Spaulding, the calcium carbonate "forms a sludge cake over the filter bed, seemingly soft and friable yet sufficiently coherent that when the filter is back-washed, this cake breaks into pieces, some an inch or more in width, floating up and down through the sand" and not passing off with the wash water; most of it remaining near the top of the sand, but some penetrating to the gravel. If magnesium hydroxide is present, the cohesion of the lumps of this cake is greater and the fouling of the bed more rapid. If the calcium carbonate and magnesium hydroxide are in unstable solution, they form a coating on the sand grains.

Unless washing methods can be improved, if carbonation is not carried below a pH of 9.0 to 9.6 the sand may require rescreening or special washing once in 5 to 10 years and the gravel layer must be watched to prevent the formation of cemented spots.

It is probable that the remedy for this trouble is some variey of surface wash. Baylis describes one consisting of a grid of perforated pipe suspended above the filter sand. Another plan employed is to use a spray nozzle attached to a ¾ inch hose to disintegrate the cake before the regular vertical wash begins.

There is generally little true floc in softened water as applied to the filter, unless coagulant is applied after softening and settling. This may preclude the use of as coarse sand as is used for simple coagulating plants.

Water of high pH acts in siliceous sand and gravel, cementing it together. This suggests use of other than

siliceous sand and gravel. The question of optimum material and size of sand is one requiring further investigation.

One of the major disadvantages of the lime as compared to the zeolite process is the amount of sludge created, which must be disposed of. Very small plants can lagoon it, or give or sell it for land treatment. Larger cities have discharged it into large streams, into abandoned reservoirs or quarries, into city sewers, or reburned it into lime.

According to C. P. Hoover, a modern lime-soda softening plant should be designed to require a minimum amount of labor in operation; be practically dust proof; provide for accurate and uniform application of chemicals, insuring a minimum variation in the hardness of the softened water; make it possible to reduce the hardness to practically the theoretical solubility limit; produce water in chemical balance; and be capable of softening muddy water as well as clear.

Zeolite Softening

Most recent zeolite plants use either greensand zeolite (found principally in New Jersey), or synthetic gels. The former is washed and hardened to prepare it for use; the latter are manufactured from precipitated solutions of sodium silicate combined with sodium aluminate or aluminum sulfate. A cubic foot of greensand will remove 2,800 to 3,000 grains of hardness, and a cubic foot of gel 9,000 to 12,000 grains, under ordinary conditions; less if the water is very hard or contains large quantities of sodium salts. The zeolite is then regenerated by passing salt water through it. Generally speaking, from 0.4 to 0.5 pound of salt is required for each 1,000 grains of hardness removed. The salt is usually delivered in bulk in cars or trucks and stored under water in underground concrete bins. From a sump in the bottom of the bin, covered with gravel resting on a perforated plate, the brine passes to a measuring compartment, is diluted to about a 10% solution, and pumped to the softening unit.

There are at present no standard tests of zeolites on the market, but such tests are being prepared by a committee of the American Water Works Association.

A zeolite softener readily produces zero hardness, but it is desirable to leave some calcium carbonate hardness to prevent the water being corrosive; and also zero hardness is not worth the cost. Therefore, zeolite-softened water is generally brought back to 50 to 70 p.p.m. hardness by mixing it with unsoftened water in the proper portions. But if the raw water contains much iron relative to the hardness, this should first be removed by aerating and filtering, or adding lime and settling or filtering through sand filters. Or all the iron and part of the carbonate hardness can be removed from all the water by the lime process, and a part of this water be softened to zero hardness by the zeolite and mixed with the lime-softened water. (Carbonates are removed more cheaply by the lime treatment and non-carbonates more cheaply by the zeolite.)

In regenerating a zeolite softener, soft water must be used for the brine in amounts equal to from 5 to 25 per cent of the water softened.

Comparison of Processes

The advantages of the zeolite process are listed by S. B. Applebaum (vice-president of the Permutit Co.) as follows: Absence of sludge; low initial cost; low operating cost; no danger of excess of chemical in the effluent; easy to operate, even with changes in composition of water; no after reactions to cause deposits; no handling of chemicals; unskilled labor can be used; hardness of effluent as low as desired. He admits that the lime soda process is more suitable for turbid waters, less likely to cause corrosion, and gives lower total solids in the effluent. As to cost, he cites estimates for a 2 mg. plant for Sewickley, Pa., of $88,000 for a lime-soda plant and $65,000 for a zeolite plant with operating charges of $30.80 and $21.65 respectively per million gallons.

C. P. Hoover states that the following information is necessary for making an intelligent choice between the two processes:

1. Is there a place available for the disposal of sludge?

If not, a lime-soda plant would be unwise.

2. Is the water to be softened always clear?

If it is turbid, a lime-soda plant would probably be cheaper than a combined filtration and zeolite plant.

3. Is the water safe bacterially?

If not, the lime treatment is desirable for its bactericidal value.

4. What is the analysis of the water?

If excessively hard or containing large quantities of sodium salts, the lime process is probably preferable. Zeolite can not soften water high in iron or manganese. Effects of other constituents are considered in No. 5.

5. Cost of salt, lime and soda ash.

To remove bicarbonate hardness, the necessary lime costs about one half as much as the salt. For non-carbonate hardness, the salt costs about 20% less than the soda ash, and the zeolite process is preferable if the water is clear.

Greensand zeolite is usually preferred when the water to be softened contains appreciable quantities of iron or is deficient in silica; synthetic gel for water low in iron or that has been sand filtered preparatory to softening.

6. Is the supply of available water scarce or abundant?

Zeolite plants require wash water ranging in quantity from 5 to 25%. If the water supply is limited, this is an important consideration. The gels require less wash water per unit capacity than does greensand; deep beds require less than shallow ones.

Lancaster Iron Removal and Softening Plant

(Continued from page 11)

construction work. Mr. Graf also had charge of the design and installation of the new wells. John Pryor and Samuel Bretler, of the Engineering Department of the Ohio State University, assisted on the preliminary investigation. The J. D. Van Gundy Co., Lancaster, Ohio, were general contractors; Burnip Construction Co., Columbus, general equipment contractors; McKeever Electric Co., Columbus, electrical work; Thos J. Corbin, Lancaster, steam heating; Chicago Bridge & Iron Co., wash-water tank; Vogt Bros. Mfg. Co., Louisville, Ky., Aer-O-Mix; International Filter Co., Chicago, filter tables, Wagner filter bottoms, controllers and zeolite.

The splendid cooperation, friendliness and help of the members of the City Council, Mayor R. W. Hastings, T. B. Cox, service director, Harry Stalder, superintendent of water works, and especially Walter Graf, city engineer, made the execution of this job a real pleasure for all concerned in its design and construction.

THE EDITOR'S PAGE

The American Water Works Association

Never before, in the more than fifty years of its existence, has the American Water Works Association faced a greater opportunity. The annual meeting of the association will be held in Chicago June 12 to 16, and by that time it is almost certain that the National Recovery Act will have been passed and the public works program launched.

Recognizing the importance of prompt and sound action, Tuesday, June 13, has been set aside for a thorough discussion of the bill as it affects the water works industry, and the program previously announced for that day has been suspended.

Obviously, the first step should be to urge and encourage the construction of new supplies; the further development of inadequate supplies; and the provision of needed purification works, including softening and iron removal. There is a tremendous want for such facilities and in the broadest and fullest sense they are needed and useful public works.

At the same time the association should exert its influence and leadership that the industry may proceed on a sound basis. Design should take advantage of the latest developments. Only the best materials and the most efficient equipment should be employed. The past two or three years have seen numerous developments in processes and materials, many of which are now fully tested and available for use.

This year's meeting of the association comes at a most opportune time, and affords an unusual opportunity for leadership to the industry. We bespeak for the association the fullest support of our readers.

Immediate Anti-Depression Action Necessary

The Federal government is doing its part and setting the pace toward recovery from non-employment. Are the City, County and State governments ready to snap into cooperative action as soon as the emergency public works funds become available?

No previous president and congress have even distantly approximated the remarkable record in legislation just made and in the making; and the most wonderful feature of this has been the speed with which such important legislation has been accomplished. And there was reason for this. More than ten million are anxiously looking for the day when they can secure employment. And for every man put to work out on the job, other men will be automatically needed to work behind the lines—in management, manufacturing, communication, transportation, finance, etc. Therefore, it is not necessary to put every one of the unemployed at work in actual construction. The Federal government is ready to spend three billion dollars, and for a large part of this expenditure asks "states, municipalities and other public bodies" to act as its agents. And the President has asked for "prompt and vigorous action."

Are we all set? Are we ready to respond?

In every issue for several months past, PUBLIC WORKS has urged public works officials to have plans ready to take instant advantage of such opportunities. Some who had done so profited by R. F. C. loans; but its powers were too restricted and it will, in a few days, be replaced by the "Federal Emergency Administration of Public Works," which will be authorized to give or loan funds for a very wide range of "useful and needed" public works.

The regulations under which these funds will be allotted will undoubtedly require a brief, clear statement of the purpose of the proposed work, definite plans and estimate of cost, and probably an outline of the procedure of construction. Those who can first furnish satisfactory information of this kind will undoubtedly be the first to benefit by these funds.

These funds are national in origin, and it would be unpatriotic, if permitted, to spend them with the foolish selfishness whose only aim would be to place all of them in local hands, regardless of economy or the ultimate good of the nation—merely a thinly disguised dole. If pre-depression economy would have called for mechanical aids in the work, get the machinery desirable and so not only profit most by the expenditure, but also help machinists in other communities, who in turn will then be able to buy the products of your own.

It is our duty to keep this money circulating; when it passes from one hand to another it is equivalent to another three billion appropriation. National circulation is much more rapid than local; the circulation of water in a reservoir is much more effective than if the same amount be contained in ten thousand tubs.

The Public Works Program and Industrial Recovery

To aid in national recovery, to supply needed public facilities, and to provide adequate service to its citizens—these are ample reasons for every community to do its share in the coming public works program.

Every community must select for itself the type and amount of work to be done, and must make its decision on the basis of its present needs, of the necessity for self-liquidation and on the demands for employment.

Sound considerations will require the use of only the best equipment and materials, the employment of most modern methods in design, the elimination of price-cutting, and the use of only qualified contractors.

Types of work selected should be chosen primarily to benefit health, comfort, convenience and trade. Therefore, most serious consideration should be given feeder or farm to market highways, water supply and purification, sewerage and sewage treatment, and adequate and sanitary refuse disposal. These affect most vitally the living conditions of the citizens, and as such are of paramount importance.

It goes without saying, of course, that with modern equipment and methods, and responsible contractors, the engineer in charge of the work should be a man of wide experience and marked ability.

Even though the money may flow easily and freely from the government coffers, no community can afford to have a second-rate job in any particular.

Relief From Water Bills

Water service connections and water rates for municipally-owned water supplies have to be regulated by municipal ordinances. When the public water supplies are owned by a private company the water services and rates are regulated by scheduled franchises approved by the State Commerce Commission.

Without changing an ordinance for municipally-owned supplies and without obtaining approval from the State Commerce Commission for privately-owned public water supplies, the municipal or water company officials have no legal right to remit water bills, and it is further their duty to shut off the water in accordance with the terms of the ordinance or the State Commerce Commission's action.

Shutting off a water service to an occupied property is, of course, a serious matter. On the other hand, the municipality or water company needs income in order to operate the waterworks system and if water were furnished free to a number of properties a large number of other people might fail or delay paying their bills, thereby making it difficult for the officials to operate the waterworks system. In order to maintain any degree of efficiency those in charge of public water supplies, whether municipally or privately owned, are compelled to treat all customers alike.

The water supply to needy families is no less a matter of relief than is the problem of providing food, shelter, fuel and clothing. It should be so considered and handled. Contact between water supply and relief agency officials should result in a satisfactory method of handling this problem.

Some water supply agencies have arranged for delinquent customers to pay bills through work created for that purpose. Some cities have paid the water bills of needy unemployed families out of funds available for relief purposes. The problem probably exists in some degree in every community which has a public water supply system. Only the local officials can determine the most practicable way to meet the problem in any community. The health not only of the families concerned but of the community makes imperative the proper handling of the problem, however.—*"Illinois Health Messenger."*

Garbage Incineration at Racine

Figures concerning the incineration of garbage at Racine, Wis., during the year 1931 were published in our issue of June, 1932. We have received from M. C. Gearen, superintendent of the city incinerator, figures for 1932, which we give below.

The same incinerator was used—a Pittsburgh-Des Moines with three 40-ton units, or a total nominal capacity of 120 tons. No refuse is burned with the garbage, but coal is used instead. Last year the amount burned totaled 10,559 tons as compared to 10,786 in 1931 and 9,553 in 1930. The cost last year was 85 cents a ton. In 1931 it was $1.05 a ton.

The plant is operated with one fireman and two charging men, each receiving $5 a day. The coal cost $4.25 a ton and power cost 4 cts per kwh. The average for the year of the amounts incinerated was 29 tons per day, but as much as 77 tons has been burned in 11 hours.

Chlorinating Milk Wastes Eliminates Nuisances

The sewage of Easton, Md., is treated in Imhoff tanks, with pre and post chlorination. A milk cooling station at one time last year was daily discharging nine tons of skim milk during a period of three hours. This seriously interfered with the operation of the sewage plant by increasing the chlorine demand beyond the capacity of the chlorine equipment, with a resulting nuisance in the receiving stream. The State Bureau of Sanitary Engineering recommended that the discharge be extended over a period of ten or more hours, reducing the chlorine demand to the capacity of the equipment.

At Taneytown, Md., a milk station was discharging small quantities of whole milk waste untreated into a small stream. The company uses equipment for manufacturing sodium hypochlorite electrolytically for sterilizing purposes, the solution containing 6% available chlorine. The Bureau of Sanitary Engineering found that 5 ppm of chlorine applied to the milk station discharge maintained 1 ppm residual chlorine 600 feet from the plant, where the waste entered the stream, and this treatment was applied during the plant's clean up period from 10 A. M. to 1 P. M., using 1¼ pounds of chlorine per day. In addition, a 30% chloride of lime solution is used for one hour each afternoon. As a result, there is a residual of over 5 ppm where the discharge enters the stream; and organic growths which previously covered the bed of the stream have been eliminated in summer dry-weather flows.

James R. McClintock

The sanitary engineering profession lost one of its most prominent members when, on April 11th, James Robinson McClintock died of a heart attack following an illness of several weeks with influenza and bronchitis. He was a member of the firm of Fuller & McClintock and had spent his entire professional career associated with Mr. Fuller, having been employed by the firm of Hering & Fuller on graduating from the Massachusetts Institute of Technology in 1906. The firm of Fuller & McClintock was organized in 1916.

He was born in 1883. The major portion of his professional career was devoted to designing plants for water supply, water purification, sewerage and sewage treatment. His best known work was his immediate charge of the design of the Wards Island (New York City) sewage treatment project. Prior to that he had been in charge of the Toledo office of the firm directing design work for Toledo, Lima and several Florida projects. Most of his time from June 1921 to 1925 was spent at Kansas City in charge of the design of the new water supply works of that city.

He was especially able in the designing of engineering works and in visualizing the more or less complicated combinations of the units entering therein and so assembling them as best to secure the objectives sought.

He was a member of the American Society of Civil Engineers, American Society of Mechanical Engineers, American Institute of Consulting Engineers, American Water Works Association, American Public Health Association and American Society of Municipal Engineers.

Mechanical Equipment in Sewage Treatment Works

By A. Prescott Folwell
Editor, PUBLIC WORKS

Addenda to Previous Chapters

I—Grit Chambers and Bar Screens

A SCREEN made by the Chicago Pump Co. consists of 15 or more hoops of equal diameter attached to a vertical shaft so as to form a cylindrical screen; the hoops being separated slightly to permit the sewage liquid to pass between them, from the outside to the inside. This screen revolves around the vertical shaft and a stationary comb removes the screenings, which fall into a pit, from which they are removed by a continuously operating inclined conveyor. This screen may be provided with a "comminutor"—steel knives which cut up into fine pieces materials which are undesirably large for pumping or passing into the treatment plant. The Lakeside Engineering Corporation are the distributors of this screen.

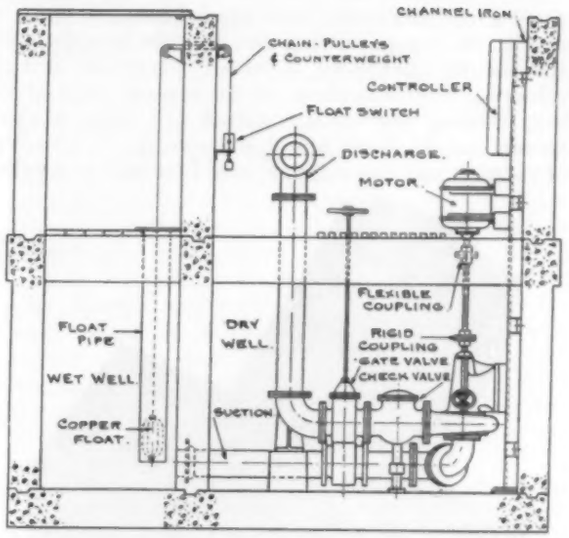
Jeffrey screen at Lancaster, Pa.

The latest screen reported is one provided by the Jeffrey Manufacturing Co. for Lancaster, Pa. An inclined bar screen is cleaned by a scraper, the teeth of which pass through the slots between the bars as the scraper moves upward. The scraper then descends in a runway removed about two feet from the screen, entering the sewage behind the accumulated suspended matter; on reaching the bottom of the channel it moves horizontally to the screen and begins to rise coming up under the screenings and carrying them to the top. Here they are discharged and a wiper automatically removes any adhering material. The control mechanism permits cleaning continuously or at intervals of from 2 seconds to one hour.

IX—Sewage and Sludge Pumps

The Jennings suction sewage pump is self-priming by means of a vacuum pump rotor, the pump being horizontal and installed above the sewage in the pump pit. Capacities range from 100 to 450 g.p.m. A similar pump is used as an ejector with capacities of 30 to 300 g.p.m.

A "screw-feed" centrifugal pump, made by the Chicago Pump Co., is supplied with a screw feed designed to cut or break up rags, rope and similar materials before they reach the impeller, to prevent clogging.



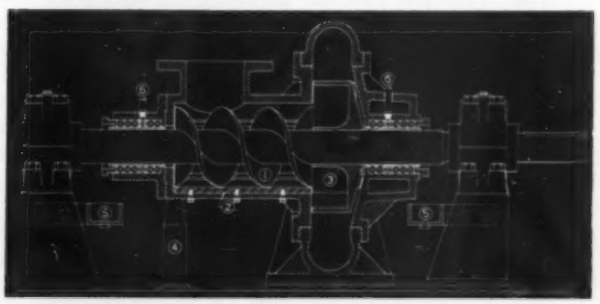
Vertical mounting for centrifugal pump. Yeomans Bros. Co.

A water seal pumping unit is made by the same company, to supply clean water for an outside water seal on pumps handling gritty matter which might otherwise cause rapid wear of shaft and shaft sleeves. It supplies 1 to 8 quarts per minute for this purpose.

A compact assembly for a small pump pit is shown in the accompanying sketch—the "Jeffery" vertical centrifugal pump mounting; both pump and motor and the controller all being fastened to one channel iron ready to be fastened to the wall of the pump pit. A small unit, with pipe connections, can be installed in a pit 3 ft. by 4 ft. 5 in., and one with 2200 g.p.m. capacity in a pit 3 ft. 8 in. by 6 ft. 11 in., and double units in pits of double the length and the same width.

X—Use of Chemicals

In the use of many of the chemicals, mixing with the sewage for some time is advantageous. This may be done mechanically or by means of air injected. As air is needed in using ferrous sulphate and lime, air mixing is especially suggested for these. An aerator mixer made by the Link Belt Co. consists of horizontal porous

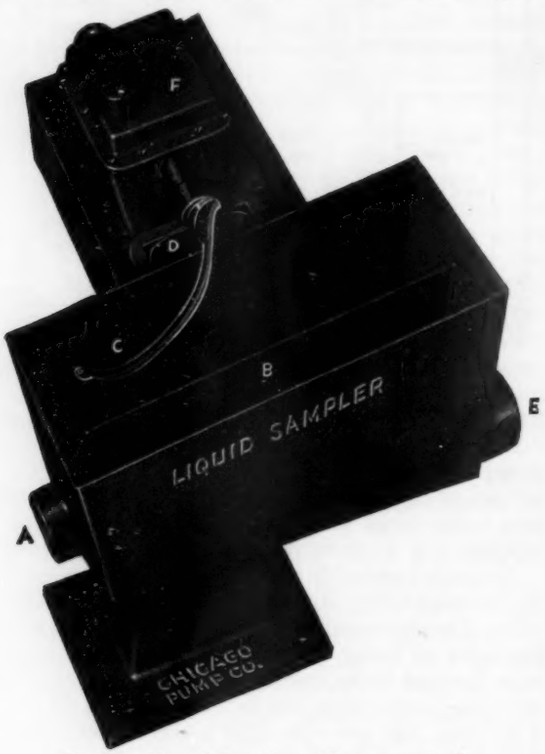


Screw-feed centrifugal pump

tubes along one side of a rectangular tank, about 4 ft. below the surface, separated by a longitudinal baffle from the rest of the tank. Air forced into the tubes and escaping into the sewage causes it to rise, flow over the top of the baffle and thence across the tank, down and again rising behind the baffle, giving a continuous circulation.

XI—General Operating Equipment

Another liquid sampler known as the "Tru-Test," consists of a small metal box divided into two parts by a baffle, the sewage flowing into one side, over the baffle and out the other side. A curved trough-like arm revolves in a vertical plane in the entrance half of the box, keeping the sewage stirred up, while a small amount caught in the arm flows down this to its center of rotation and into a funnel and from this to a gallon



Tru-Test Liquid Sampler with top removed.

bottle. The speed of revolution of the arm can be set for once every 2, 3, 4 or 5 minutes. The samples taken are so small that the gallon bottle will usually hold a composite sample for a 24-hour period. It is operated by a motor using 40 or 50 watts.

Circulating Imhoff Tank Sludge

The Veterans' Home Building Commission has lately completed, at Rocky Hill, Connecticut, a sewage treatment plant designed to care for the wastes from a population of 1,000 persons, which will be increased to 2,000 if the full plans of the commission are carried out. The plant consists of coarse screens, an Imhoff tank 31′x19′x25′ deep, a glass-covered sludge-drying bed 48′x23′, and a 12′x16′ brick tool house and laboratory for the attendant at the plant.

Although all the sewage and sludge flows through the plant by gravity, the engineers, Henry Robinson Buck, Inc., felt that a pump should be available to circulate the sludge in case its character needs to be modified or to empty the tank if it ever becomes necessary to do so. Accordingly two 3″ galvanized pipes were hung vertically in each hopper of the tank, one with its lower end at the bottom of the hopper, and the other ending two feet below the slot of the upper or flowing-through chamber.

If it is desired to mix old sludge from the bottom of the tank with fresher materials from the top of the hopper or with surface scum, the pump can be attached by means of flexible hose to the upper end of either or both of these pipes, and the sludge will be circulated as desired. Also, lime can be added in connection with these operations if the sludge becomes unduly acid.

An SS-3D, 3″ "Domestic" diaphragm force pump was purchased for this work. This is easily rolled out from the tool house by one man, and, because of its portability, is also available for any pumping work likely to be needed on the 700-acre property of the Home.

The Sanitary District of Chicago and the Depression

The U. S. Supreme Court in April, 1930, ordered the Sanitary District of Chicago to construct and operate sewage treatment plants so that it could reduce the amount of water withdrawn from the Great Lakes through the drainage canal and the amount of pollution reaching the lower Mississippi river; which plants are estimated to cost about $270,000,000. Up to June 1, 1932, the district had completed work valued at $100,119,680, which included about 55% of the Calumet project, 90% of the North Side project, 40% of the West Side project, and about 1½% of the Southwest Side project, miscellaneous plants and sewers and Chicago River controlling works, estimated at $85,300,000.

The actual sewage treatment in operation on June 25 was estimated equivalent to 100 per cent treatment of 31.6 per cent of the total sewage within the district.

But less than $300,000 worth of work has been done since December 1, 1931, when almost all work was discontinued for lack of funds; the only new contract let having been one awarded March 24, 1932, for constructing a sludge filtering and drying unit at the West Side plant, made possible by using tax anticipation warrants. The district has $43,000,000 of authorized bonds for sale, but has been able to obtain no reasonable offer for them. It has paid no current bills nor any money due contractors since November 1, 1931, except in a few cases where the payee could find purchasers for tax anticipation warrants. Also it is in default on principle and interest on $7,600,000 of bonds due on or before July 1.

The personnel of the engineering organization connected with the construction program has been reduced 64% since last December, and the salaries of those remaining have been reduced since January 1, 1932, and unpaid since April 1.

These figures are from the semi-annual report of the district to the U. S. Supreme Court. They show that the district is not complying with the instructions of the court because it can not. The court apparently can do nothing about it except grant an extension of time.

Helpful Hints on Sewage Works Operation

By F. M. Veatch
With Black & Veatch, Consulting Engineers, Kansas City, Missouri

THE use of mechanical equipment has become quite general in the modern sewage disposal works, and while it has decreased the amount of disagreeable hand labor, its intelligent care and operation has added a new responsibility to the long list borne by the plant operator.

A sewage disposal plant equipped with mechanically cleaned screens, incinerator, grit chambers with apparatus for collecting and washing the grit, pre-aeration tanks for grease and hydrogen sulphide removal, mechanical clarifiers, sludge-digesters equipped for heating and gas collection, and other mechanical devices, offers the operator what might be called a sporting proposition. If used intelligently, in accordance with a program which has been carefully worked out to fit local requirements, he wins. If not, surprising things can and do happen.

Remarkably few of the operating difficulties are of a mechanical nature but the main trouble seems to lie in the failure to coordinate the various operations into a suitable program. The formulation of such a program seems to be typical of sewage disposal in general in that no set rules can be laid down. Success seems to lie in cut and trial until the program most suitable to local conditions is worked out. Some experiences with mechanical equipment may serve to illustrate this point.

Screens. At Grand Island, Nebraska, a mechanically cleaned bar screen with ½-inch openings was installed to protect the sludge pumps. The mechanical operation was above reproach, but it was found that from 6 to 8 cubic feet of very offensive matter, which drained very slowly, was intercepted from a sewage flow of 1.6 m.g.d. This greatly exceeded the capacity of the incinerator and, due to the large amount of offensive matter included and the relatively low temperature attainable in the incinerator, its disposal by this means caused an undeniable nuisance. The openings in the bar screen were increased to 1¼ inches, with the result that from two to three cubic feet of relatively clean screenings are produced daily. This drains readily and is incinerated with little or no odor. No pump trouble has been caused by the change, and in this case, at least, the smaller particles which pass the 1¼ inch screen, but were formerly intercepted by the ½ inch screen, are handled much more readily as sludge than as screenings.

The screen chamber at any plant is likely to be a source of nuisance, since it is usually necessary to reduce the velocity in the screen channel and more or less sludge is deposited. If this is allowed to accumulate for any length of time, it naturally becomes offensive, but if the channel is cleared daily, it is usually not noticeable. This is done very readily by a series of fixed water jets. At the Coal Creek plant at Tulsa, Oklahoma, a few minutes' agitation serves to stir up the sludge and it passes through the screen to the plant.

Compressed air has been used with similar results at Osage City, Kansas.

Incinerators. The incineration of screenings in a small plant using equipment in which high combustion temperatures cannot be maintained is a rather precarious procedure, since the screenings must be relatively dry and free from much offensive organic matter.

At Tulsa, Oklahoma, Wichita, Kansas, and Dodge City, Kansas, screenings from 1-inch bar screens are successfully incinerated with digester gas as fuel. This screen size seems to be about the lower limit for use with small incinerators.

In each of these cases the digester gas is used primarily for heating the tanks, and therefore only the excess gas is available for incineration.

Grit Chambers.—The mechanical removal and washing of grit eliminates the nuisance which usually attends the cleaning of grit chambers, but in small plants where the expense of this equipment is not justified and where enough grit reaches the plant to make its removal advisable, this problem is quite important. At both Dodge City, Kansas, and Grand Island, Nebraska, some street wash enters the sanitary sewers and a considerable amount of grit reaches the plant. At ordinary flows, deposition of sludge takes place in the grit chambers, and to keep this from becoming a nuisance it is stirred up by a water jet at frequent intervals, and most of the organic matter is carried on to the tanks.

Pre-Aeration Tanks. The application of air for a short period before settling is of benefit, since it brings a great deal of the grease to the surface where it may be skimmed and, in the case of septic sewages, it helps to keep down odors by scrubbing out the hydrogen sulphide and other noxious gases.

At Whittier, California, a fifteen-minute aeration period previous to Imhoff tank treatment has made a notable difference in the amount of odor from the sprinkling filter sprays. At Dodge City and Abilene, Kansas, hydrogen sulphide is commonly present in the raw sewage during warm weather, but after aeration is not noticeable in the tanks or at the outfall.

Due to the scum of grease which commonly forms on the surface of these tanks, frequent hosing down of the walls, especially at the water line, is advisable.

Clarifiers. The operation of clarifiers of all the types in general use is largely a matter of oiling, sludge pumping and skimming. If sludge is allowed to accumulate on the bottom of the tank, some of it will of course rise to the surface within a few hours. Persistent rising of sludge is usually a sign that it is not being removed quickly enough and the answer is longer or more frequent pumping periods but even with the best regulated tanks, occasional sludge masses reach the surface and the use of a hose once or twice daily is advantageous.

Many of the clarifiers have skimming devices which remove scum along with more or less water. At Wichita, and Dodge City, Kansas, this mixture is discharged into small tanks and allowed to separate. The water is removed through a siphon and the grease is dipped out into pails for incineration or burial.

Sludge Pumps. With suitable screens on the raw sewage, the pumping of sludge is usually simple from a mechanical standpoint. The frequency and length of the pumping periods seems to be a matter of trial in the individual plants. Short pumping periods at hourly intervals appear to be better than longer periods of less frequent intervals. The sludge pumpage varies quite widely in different plants. At Grand Island, Nebraska, approximately 6,000 gallons of raw sludge is pumped

per million gallons of sewage, while at Dodge City, Kansas, the figure is approximately 5,400 gallons.

A common defect in sludge pumps is inadequate air chamber capacity. Extremely high pressures are built up in the discharge lines in the absence of the cushioning effect of air and based on experiences at Dodge City and Abilene, an allowance of four or five times the air chamber capacity required for water service is advisable.

Digesters. The outstanding feature of sludge digester operation is their temperamental nature during the first few months of operation. After the proper action has started, they seem to require nothing more than a rational program of filling and emptying.

Two digesters, in separate plans, at Tulsa, Oklahoma, were started in August, 1931. Lime was added daily and the pH was kept above 7.0. Gas production reached a little over .5 cubic foot per capita during October and from this time on digester temperatures have been kept well above 80°F. At Wichita, Kansas, where lack of funds has precluded full time plant operation, the three digesters have been filled very slowly and alkaline digestion has come about in a natural way with no foaming or other troubles. Possibly this is an indication that new tanks may be started too rapidly and that it might be well to dispose of part of the sludge elsewhere until the tank has a chance to become alkaline.

General. The foregoing paragraphs cover only one of the many phases of plant operation, and the experiences on which they are based were obtained at only a few of the three thousand or so plants in the United States.[1] These experiences, however, illustrate the general truth that while mechanical equipment has reached a commendable state of development, the operator still has to do his own thinking.

The importance of the operation phase of the sewage disposal problem has been recognized for many years, and a surprisingly extensive literature has been built up around this subject. It is indeed a rare operation trouble that has not been discussed in the text books or in the technical press, by those who have had personal contact with it.

Probably a great deal of the accumulated data is not available to all operators, but it would seem that the man in charge of even the smallest plant could benefit himself by procuring enough literature, relative to his particular process, to enable him to understand the purpose of his plant and its limitations. A request to the designing engineer or to the state health authorities will give the necessary references. Membership in state and national sewage works associations is now available to the majority of operators and the yearly dues, as well as the expense of attending the meetings, is a legitimate charge against the operation of the disposal plant.

Naturally, when serious trouble arises at the disposal plant, it is a matter to be discussed with the designing engineers or the state health authorities, but many of the minor difficulties may be eliminated by a knowledge of the experience of others.

One cannot follow the literature on plant operation without being impressed with the wide scope of the subject and its variable nature. Successful methods in one locality are failures in others. Success in overcoming difficulties seems to lie in the trial of various methods until the right one is found.

Possibly the main thought in this article may be emphasized by paraphrasing one of Rudyard Kipling's poems, "The Ladies."[2] The two subjects are similar in that neither is any too well understood, both are important, and good advice on either is valuable.

"Sewage Works Operation"

I've run all my plants as I've found 'em;
  I've taken advice all the time;
I've 'ad my pickin' of troubles;
  An' four o' the lot was prime.
One was a clogged up sludge pump,
  One was an old tank that foamed,
One was a filter that wouldn't pass air
  An' one was an odor that roamed.

Now I aren't no judge of the methods,
  For, takin' 'em all along,
You never can tell 'til you've tried 'em,
  An' then you are like to be wrong.
There's times when you'll think that you oughta,
  There's times when you'll know that you can't;
But the things that you'll learn from Mohlman[3]
    an' Downs,[4]
  They'll help you a lot with the plant!

Now I was a new one with sludge pumps,
  A callow and dumb little squirt;
Little I knew that a big iron pump
  Would balk at a blue flannel shirt;
"Screens," says the book,[5] "is important";
  "Without 'em the pump will stop flat";
So I strained out the rags, the sticks and the bags—
  An' I learned about sludge pumps from that!

Then the old Imhoff tank started spewing,
  The insides were coming right o'er,
Restin' was good but not trusty
  An' mixin' it helped quite a store.
"pH," says Old Bill,[6] "is essential"—
  "Too low and your tank won't stay still,"
So I shoveled in lime for a heck of a time,
  An' I learned about foaming from Bill!

My filters was loaded with Fungi,
  Psychodae pervaded the place;
My troubles became overwhelming;
  An' wrinkles enveloped my face.
"Chlorine," says Smith,[7] "is the answer"—
  "Forget all your troubles forthwith"—
So I dosed up the tank with this chemical rank
  An' I learned about pooling from Smith!

I was staying up nights over odors,
  The neighbors was after my hide—
Deep was my thought on the subject,
  Many the cure-alls I tried.
"Clean up," says Cohn,[8] "and you're over";
  "Keep clean, and your troubles will dim";
So I washed up the place with a smile on my face,
  An' I learned about odors from him!"

I've run all my plants as I've found 'em,
  My battle I think I have won,
The more that you learn of the others
  The better your luck with the one.
The answer is sittin' and readin',
  An' thinkin' new methods to see;
So take heed from my lot (which I know you will not)
  An' learn about sewage from me!

* * *

What did the wise designer think?
  Nobody never knew.
Somebody asked the plant man
  An' he told 'em true!
When you get to the guts of the thing,
  They're like as a row of pins—
For the Big City drain and Podunk's lone main
  Are sisters under their skins!

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For 44 years this water system remained unchanged, then Dover elected a progressive mayor and council who brushed off the cobwebs and started things happening.

How a Losing Water Works Plant Was Made Profitable

By L. D. Shank
City Manager of Dover, Delaware

THE water system of Dover, Del., was installed in 1881, and the sewers in the main sections of the town in 1909. When the town in 1925 elected a progressive mayor and council, nothing had been added to or taken from these systems in all the intervening years. The water was a direct pumping system, with no storage or reserve. The supply was obtained from three 8″ and one 6″ wells 200 ft. deep, lifted by air into dug wells 14 ft. in diameter and 30 ft. deep, lined with concrete. From these it was pumped into the mains with De Laval two-stage centrifugal pumps, driven by 30 hp. squirrel-cage motors with current supplied by the municipal electric plant. A head of 175 feet at the pumps was maintained. Most of the mains were 6″ and 4″ cast iron pipe laid in 1881, with a small percentage of 8″, and contained very few valves. The air for the air lift was furnished by an old steam duplex compressor.

When the writer took charge of the light and water department in 1926 changes were immediately begun in these deplorable conditions. We at once purchased an electric driven air compressor, thereby cutting down the pumping cost materially. We also installed a 500 kw. turbo-generator unit, which made great savings in the generation of current. A 12″ well 207 ft. deep was put down and our supply was thus made reliable so far as was possible with direct pumping. Numerous extensions were made to outlying sections, which had been made necessary by the extending of town limits.

In 1928 we reinforced our distribution system by laying 14″, 12″ and 10″ mains, feeding into the old system at two block intervals, and installed an elevated tank, which provided storage and gave a uniform static pressure over the town of an average of 52 lbs., making it possible to deliver in the business section 2,000 gpm. for fire protection at any time. This water is of the safest quality; it has rather a high percentage of hardness but is good tasting and is not treated in any way.

In 1929 we installed in the 12″ well referred to a deep-well Byron-Jackson centrifugal pump having a capacity of 750 gpm. against 208 feet head. This pumps directly into the mains and has cut our pumping cost exactly in half. It is automatic in operation, working on a 4-foot variation in head, and is equipped with a 50 hp., 2300 volt, 3-phase motor, operating at 1750 rpm.

The 12″ well, which has a 31 ft. Cook brass strainer and is sealed at both the top and bottom of the strainer, has shown continuous improvement in capacity since the deep-well centrifugal pump was installed. I feel, in the light of personal experience and observation, that large wells are preferable to a number of small wells with driven strainers, in which it is necessary to use suction pumps, which may result in leakage of surface water into the system, making treatment necessary to avoid possible contamination.

The observance of some of the details referred to and the simplification of the pumping details will frequently spell the difference between a costly utility and one which will bring a nice profit into the treasury. The securing of such a system can be obtained only by employing reliable and experienced engineers.

Improvements in the municipal electric plant, the latest made last year, increased its capacity from 400 kw. to 2500 kw. and reduced the cost of current from 7 cts. per kw. at the board to 8 mills. Last year the average pumpage into the main was 750,000 gpd. compared with 450,000 in 1926, in spite of which the cost of pumping was reduced from $1200 a month to $500. The profits of the water works for the year 1925 were about $5,000, but nothing was charged for current for pumping and the electric plant lost that same amount.

The electric utility now charges the water department a flat rate of 3 cts. per kw., which includes repairs and all attendance to the water pumping department. We estimate that this is equivalent to a rate of 2 cts. for the current alone, which, although it is low, is considered sufficient.

Our water profits for 1932 were over $12,000, and for the electric department $87,818. This would indicate profitable utilities, aside from the reliable and dependable service with low rates. There has been no interruption of water service except after midnight when, because of the absence of valves, we cut off water to make changes.

One of my first steps was to meter all consumers. One customer was paying the water department $150 a year, but when a meter was installed the bill jumped to $3,000 annually at 10 cts. per thousand gallons. Metering another company's service added $600 annually to the water treasury instead of $50.

Our meter rates are 25 cts. per thousand gallons for the first 50,000 gallons per quarter, and 15 cts. for all above that. Flat rates for residents are $5 for the first cold water spigots, namely, kitchen sink, bath and stand, and toilet and pave wash, and $3 per year for each additional outlet.

The method of accounting should furnish sufficient information to permit the superintendent or manager to know at a glance whether or not each department is working efficiently, or whether the installation of work is expensive or done at a saving over previous jobs. He should be able to know exactly what it costs to deliver water or electricity to the consumer. There is, however, a grave possibility of having an accounting system overburdened with detail, involving the employment of expensive personnel that over-balances the benefits to be derived from the knowledge gained. I feel that excessive overhead is often required by the demands of Federal and State bodies that utilities keep an enormous amount of data, the cost of which burdens them with an excessive payroll which is often unnecessary for rendering service on an economical basis.

with

GOODYEAR PNEUMATIC LUG TRACTOR TIRES

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SPECIFY GOODYEAR PNEUMATIC LUG TRACTOR TIRES ON NEW GRADERS AND MAINTAINERS

For reviews of special booklets on maintenance—turn to pages 51 and 52

Development in Low Cost Tar Surfacing

By A. R. Taylor, Engineer
Tarmac Department, Koppers Products Co.

OUR highway systems contain many miles of expensive pavements constructed where traffic requirements have not warranted the expenditure. Adjoining many of these high-cost pavements are less-expensive types of paving that are satisfactorily meeting the needs of traffic. Coupled with this fact are the two current conflicting demands of the public, which on one hand is clamoring for an extension of surfaced-road mileage, and on the other hand is loudly demanding a rigid curtailment in public expenditures to relieve the burden of taxation. The obvious solution of this situation is the further development of low-cost types of pavement capable of handling traffic requirements. In many cases this development is essential to the completion of surfacing on primary systems, and, still more important, for the establishment of needed all-weather rural highways so necessary for the welding of all of our roads into one sound transportation system.

For the last few years many engineers have recognized the necessity of developing satisfactory low-cost bituminous surfaces and have been experimenting with surface treatments on old roads which heretofore have been considered unsatisfactory for such types of surface: also with road mixes of bituminous materials and various grades of available local aggregate. Naturally, some failures were experienced, but the treatments on the whole gave such satisfactory results that many states, and the Bureau of Public Roads, became interested in the possibilities and conducted further experiments. Such rapid progress has been made in the development of low-cost surfacing that today there is a type that can be used satisfactorily with almost any kind of local aggregate.

As tars have played an important part in the development of low-cost bituminous surfacing, we will outline some of the types in use today and the trend in the construction methods used to build them.

Volume of Traffic Which Can Be Carried

The paving of any road, whether primary or secondary, should be designed in accordance with local conditions and the traffic demands made upon it.

Of the various low cost bituminous surfaces, we find surface treatments successfully carrying as high as 1,500 vehicles per day, and mixed-in-place surfaces up to 2,000 vehicles per day. As the great majority of our farm to market roads carry

Applying Tarmac prime on topsoil, Pickens Co., S. C.

lar less than 1,000 vehicles per day, a vast field is opened to the low cost surface treatment. This type of road has the added advantage that it may be satisfactorily topped at a later date with a mixed-in-place or similar type of surface if traffic increases sufficiently to warrant it.

In the January (1933) issue of Public Roads appeared a joint article by J. S. Williamson, Assistant to the South Carolina State Engineer, and Paul F. Critz, Associate Highway Engineer, Bureau of Public Roads, explaining the results obtained from an eight mile experimental top soil road built jointly by the Bureau and the South Carolina State Highway Department, on which various types of bituminous treatments were used in surfacing. The composition of the soil consisted roughly of 78% granular material, 14% silt and 8% clay. Of the 78% of granular material, over 90% passed a ¼" screen.

When the surface treatment was applied in 1924 this road carried an average of 636 vehicles per day and a maximum of 800 vehicles, whereas in 1930 it carried an average of 956 vehicles and a maximum of 1,402 vehicles per day. To quote from the report, "The maintenance cost of the sections, with the exception of the first year after construction, which usually is relatively high, continued very uniform in spite of the great increase in traffic."

Over a six-year period the maintenance cost varied in accordance with the sections, ranging from $135 to $460 per mile annually—averaging $345 per mile. The report further stated: "The cost of maintaining the wearing surface of the project through the six-year period—while varying among sections—is considerably less than that of maintaining an untreated top soil carrying much less traffic." Certainly this shows the advisability of treating macadam, gravel and soil roads, particularly in view of the added advantages obtained by eliminating the dust and mud nuisance.

There are today being maintained many untreated macadam, gravel and similar type roads at a higher cost than those same roads could be maintained were they given a tar treatment. With the many traffic advantages due to the dustless all-weather surface, it is hard to understand why a greater percentage of these roads have not been treated.

1. Surface Treatments

The surface treatment of macadam and gravel roads is not new, but the demand for dustless and mudless roads has greatly extended its use so that today surface treatments are used successfully over various types of roads. In this work care must be taken to see that the road is properly drained and the surface properly shaped; and that the base is thick enough to withstand the traffic loads to which it will be subjected. Although sand-gravel roads may be treated immediately after construction, ordinarily, better results are obtained if clay, gravel and similar roads are left open to traffic for a period of six months or more after completion to allow thorough compaction and the development of any weak spots in the surface which can be repaired before the tar treatment is added.

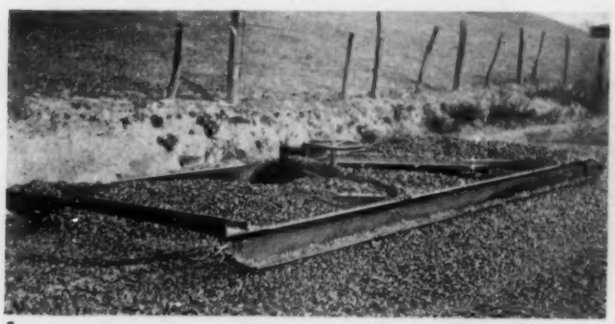
Formerly, a light grade of cold application tar was used almost exclusively for surface treatment work. It is still used extensively for prime coat on new treatments, and on account of its penetrating and binding qualities is the most satisfactorily and universally used material for this purpose. Although it may be used successfully for seal coat and retreatment work, it is not recommended, as better results are obtained with heavier grades of tar, which hold more cover material and are better adapted for dragging.

More attention is being paid to the cover material, with the result that better grades and sizes of material are being used. Dragging the surface is meeting with increased favor as dragging not only mixes the cover material with the tar, but shortens the length of time for the treatment to set up, greatly reduces the amount of cover material whipped off the road surface by traffic, and most important of all, produces an extremely smooth-riding surface. Many types of drags have been used, from brush, pulled behind trucks, to long steel drags weighing more than 7,000 pounds. All have helped improve surface treatment work, but the present tendency seems to favor long base, broom or steel drags.

Drag treatments give excellent results when the proper grade and quantities of tar are used. We all know from our own experience with retreatment work that some surfaces are more porous than others and require different quantities of bituminous material for the same quantity of cover. Where light grades of bituminous material are used with an excess of cover material, the aggregate, although uniformly coated after dragging, retains such a thin film of bitumen that it does not become properly bonded to the road surface. For these reasons, more viscous grades of tar than heretofore used for surface treatment work are advocated, together with close control over the amount and grade of cover material used.

One mistake frequently made is to specify a definite quantity of tar and cover material for all classes of retreatment work. This is bound to

(Continued on page 39)



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"DRAGGING THE SURFACE IS MEETING WITH INCREASED FAVOR . . ."

1. Long base drag
2. Wooden drag.
3. Broom drag used to distribute chips over hot treatment.

Roads like this, when well maintained, are suitable for farm-to-market transportation

Maintenance Equipment: Its Suitability and Utility

By C. N. Conner

THE purpose of this article is to tell how experienced maintenance engineers determine and use equipment best fitted to the essential steps of road maintenance. The facts, available through the courtesy of the American Road Builders' Association, were furnished by men whose life work has been maintaining highways. They are agreed that *basic requirements in equipment for economy are mobilty and diversity of use*. Mobilty, particularly, is essential if they are to maintain properly the large mileages of serviceable roads now made possible by developments in low-cost surfaces.

Worn-out and obsolete equipment has no place in modern maintenance. Operation cost records show that modern equipment has longer life, lower repair costs, lower depreciation rate, does better and more work, and reduces maintenance costs.

The tasks to be done and the results obtained by suitable equipment are:

1. Maintaining right-of-way.
2. Maintaining soil roads.
3. Maintaining gravel surface types.
4. Maintaining bituminous treated roads.
5. Maintaining pavements.

1—Maintaining Right-of-Way

This includes cutting and clearing brush, weeds, stumps and grass; digging new ditches and cleaning old ones; preserving existing trees and shrubbery; and planting new growth, flattening slopes and planting grass; cleaning old culverts and building new ones; erection and maintenance of guard rail.

Common practice is to use axes, brush hooks, and scythes for cutting weeds and brush. At some places where it is necessary to clear logs or stumps, stump pullers or blocks and tackles are used. Clearing forces are equipped with a truck and tractor when using block and tackle or stump puller.

For ditching and clearing of ditches, hand shovels are used, leaning wheel graders, Martin ditchers and, in some cases, a trench hoe or power shovel. With the road grader the material is bladed to the surface of the road; in case of soil roads, where this material is satisfactory it is mixed into the surface of the road; in other cases it is hauled away on trucks and used to repair and widen fills. The Martin ditcher is used to open up small ditches and with it the material is pushed to the back side of the ditch. Where a trench hoe or power shovel is used to open up large ditches, the material is usually hauled away on trucks and deposited along the slopes of fills.

For cleaning earth from culverts, sectional handled shovels, push rods and cables with buckets attached are successfully used.

Sprays of chemicals kill bushes and destroy vegetation, which are of value as a protection against erosion and wash-outs during heavy rains. Bushes are cut about twice during the summer while they are tender, for which it is believed that bush axes and scythes are economical tools.

Agricultural type mowing machines, equipped with rubber tires and pulled by a light truck or wheel tractor, are used for cutting weeds and grass along shoulders and on part of the right-of-way. Motorized one-man units for this purpose have reduced costs.

For cleaning and thawing pipe culverts, long-handled hoes, collapsible devices with extension handles, blow torches on long handles, calcium chloride and portable steam boilers with hose are used with good results.

2—Maintaining Soil Roads

In midwest practice, the type of equipment used depends upon the topography and the soil texture. The type of grader commonly used is the 8, 10 or 12-foot straight-blade grader, usually equipped with scarifier and back sloper and steerable tongue controlled by the operator. Probably no other piece of road equipment is so universally used.

Patrol graders are now in common use, equipped about the same as the ordinary straight-blade grader except that the power unit is an integral part of the grader. These are not as flexible as the straight-blade grader pulled by tractor power.

The elevating grader is very successful in flat country where it is not necessary to make too many short turns. It is equipped with a rotary disc or plow for throwing the earth onto the belt conveyor, which is usually 36 or 42 inches wide. These graders do not operate so well in soil filled with rock.

In cutting down shoulders and opening ditches or redressing back slopes, the ordinary grader may be used with a back-sloper to throw the earth upon the shoulder or along the edge of the road in a windrow. This earth may be reclaimed by the use of slip scrapers, fresnos or maney scrapers; or with small portable shovels, bucket

loaders, truck cranes, hydraulic diggers or equipment of that type; but where only a small amount is to be moved, it probably would be more economical to shovel direct into the truck with ordinary hand shovels.

One southern state maintains sand-clay and top-soil roads satisfactorily with the following equipment:

Tractors—All sizes, both wheel type and track-laying type.

Trucks—All sizes from 5-ton down, with gravity and hydraulic lift bodies.

Graders—All sizes.

Maintainers—All sizes.

Small tools—Axes, bush hooks, scythes, picks, shovels, etc.

The usual method of maintaining soil surfaces is to dry-drag twice per week in dry weather, using a light tractor (2 to 5-ton) or heavy truck (2 to 3-ton) pulling two 8-ft. graders or a 3-way drag, or a heavy truck with an under-body scraper. The surfaces are dragged or machined after each rain if sufficient to give the surface a "season" using the same equipment. In case the road is badly corrugated a heavy tractor (5 to 10-ton) is used pulling one or two large graders (10′ to 12′). This outfit usually parts the surfacing material from the middle of the road to the sides and then pulls it back in. Usually the cutting is done to the bottom of corrugations.

Trucks are used to patch holes, build up thin surfacing and transport men and equipment. In patching top-soil, clay-gravel, clay-bound macadam and sand-clay, it is best to clean out all loose material, lightly scarify or roughen the surface of the hole or depression, sprinkle the roughened surface with water and then patch with moist soil.

3—Maintaining Gravel Surface Types

The traffic-bound road is the most popular type of gravel or stone road because of its low cost and general adaptabilty. The same equipment types are used for both its construction and maintenance. It is, therefore, selected as typical and illustrative of modern good practice in gravel maintenance.

Although traffic does most of the compaction, the use of special type rollers such as the sheeps-foot roller greatly accelerates compaction and reduces wear on tires. The equipment on a typical gravel job using local material includes a crushing and screening plant, trucks with either end or bottom-dump bodies for hauling, and a blade grader for spreading.

When local gravel is used, the crushing and screening plant is set up in the local gravel deposit, from which the surface has been stripped by teams and scrapers or by rotary scrapers drawn by small tractors. The material is delivered from the plant directly into the trucks, which haul it to the roadway and dump it along one shoulder. A smoothing unit (either a tractor drawing a blade grader or a motor grader) windrows the material into more compact form and spreads a small portion of the gravel over the roadway under traffic. Thereafter from time to time small additional amounts are brought in under traffic as fast as the material can be compacted, and smoothing is more or less continuously carried out by the sectionman. In removing the excess sized material from an old road it is usually scarified and the over sized material raked off or moved to the side of the road with maintainers or York rakes.

For preparing glacial pit gravel and river gravel, the plant is usually a one-unit screening and crushing plant consisting of a power unit, crusher, either rotary or horizontal shaker screens, a three-yard bin under the screen, a delivery belt conveyor to the truck, an intake belt conveyor to hopper, and a three-quarter yard drag line with double drum hoist with power unit to convey the material into the hopper. The capacity of these plants ranges from 200 to 300 cubic yards per day. Excellent materials, when obtainable from commercial plants, usually cost less.

Electro-magnets mounted on trucks for removing metal scrap and waste from gravel surfaces are proving economical and efficient and more general use of this type of equipment is expected. One of these devices collected 27,000 pounds of metallic articles in 146 days, an average of 3.76 pounds per mile of operation.

For dust prevention, calcium chloride is spread by lime drills or chip spreaders; or road oils are spread by commercial distributing tanks.

Equipment for maintaining bituminous treated roads and city pavements will be discussed in the next issue.

Only Four States Authorize Diversion of Gas Tax

Proposals to divert the revenues from the gasoline taxes to purposes other than the building and maintenance of highways appear to be increasingly unpopular. In a great majority of the legislatures of 44 states, which were in session during the early part of the year, bills were presented to utilize this revenue for various purposes but in only four were they passed, according to a legislative analysis being made by the National Highway Users' Conference. These states were Alabama, South Dakota, Tennessee and Florida.

The diversion measure adopted in Alabama provides that Clay County may use 20 per cent of the gasoline tax turned over to it for school purposes. In South Dakota, one half of the proceeds has been diverted to the Rural Credits Fund, and the extra 1 cent voted in Florida goes to the General Revenue Fund. The diversion in Tennessee affects only counties with population between 7,120 and 7,130. In such counties one half of the gasoline tax proceeds may be used for whatever purpose the local authorities may desire.

In 1932, according to a compilation of gasoline tax statistics just made by the Bureau of Public Roads of the U. S. Department of Agriculture, more than 10 per cent of the $500,000,000 collected was diverted to other than highway purposes. This amount was nearly one and one half times as great as that diverted in 1931.

Proposals to increase the state gasoline taxes were also rejected in many of the states where they were offered, according to the Conference survey. The only actual increases were in Florida, Tennessee and Oregon. The tax in Florida was raised from 7 cents to 8 cents, giving that state the distinction of having the highest state gasoline tax. Actually Alabama should be accorded that honor because in addition to the state tax there are levied certain county and municipal taxes. The state tax, however, remains at 6 cents. Tennessee is a close contender for the leadership, its tax having been raised from 7 to 7½ cents. The Oregon tax has been boosted from 4 to 5 cents. It was in Oregon that the first gasoline tax was levied.

A special and as yet unique tax was provided in Maryland, authorizing the collection of 4 cents a gallon on all gasoline used by non-resident owned trucks on which the Maryland tax has not been paid. The State Roads Commission is given the authority arbitrarily to determine the taxable amount.

In addition to all the state taxes, there remains the 1 cent Federal tax imposed at the last session of the Congress.

Soil Stabilization in Highway Construction Through Calcium Chloride

SOIL stabilization principles are not new, but technique for their practical application in gravel road building remains largely to be developed through field practice. Many of the state highway departments include divisions devoted to the study of this subject. The Calcium Chloride Association is developing a special corps of field service technicians and has engaged Fred Burggraf, formerly of the Highway Research Board. With the cooperation of the Bureau of Public Roads, it is believed that analyses of soil properties can be adapted to simple mechanical tests for field application. With such data, it will be possible to balance the composition of local soils to attain a maximum degree of structural stability considering their frictional, plasticity, shrinkage and absorption factors.

In this connection, a discussion by H. F. Clemmer of some of the points included in the experiences of R. B. Traver in Onondaga County, N. Y., is of interest. (See PUBLIC WORKS, page 27, April, 1933, for an account of Mr. Traver's work.) An abstract of Mr. Clemmer's comment follows.

Investigations are being made of both physical and chemical admixtures and manipulation required to change clay, silt, or sand subgrade into semi-solid constant volume road slabs, capable of accommodating a large volume of traffic, and even heavy traffic, when covered with only a relatively thin wearing course. The problem is to create a subgrade which will not soften up in the presence of moisture; that is, one that will not readily absorb moisture.

Research Projects Studied

Two years ago the Highway Research Board of the National Research Council established a committee of engineers to study the use of calcium chloride for highway construction and maintenance. Several research projects under the direction of the Highway Research Board were started in the summer of 1931. One project was in South Carolina on a sand-clay road and another in Missouri on a gravel road. Tests were made which showed:

(1) Calcium chloride-treated sand-clay soils did not lose moisture at as rapid a rate as the untreated soils of the same character. The time required for a treated sample to lose all of its moisture when dried at temperature of 80-100° F. was twenty-seven days, while the untreated sample dried in three days. The chloride content of the treated sample was 1.25 pounds per square yard.

(2) A factor of interest in the Missouri investigation was a check made to determine the loss of road material by comparing the dust collected on treated and untreated sections. The results indicated that fifty per cent less dust and fine material was collected from sections treated with calcium chloride.

Study during the past year, 1932, was continued on these projects and a new project was started in Nebraska. In order to determine the best method of using calcium chloride, three poschemical reaction with the soil, (2) rainfall, and chemical reaction with the soi,, (2) rainfall, and (3) maintenance manipulation.

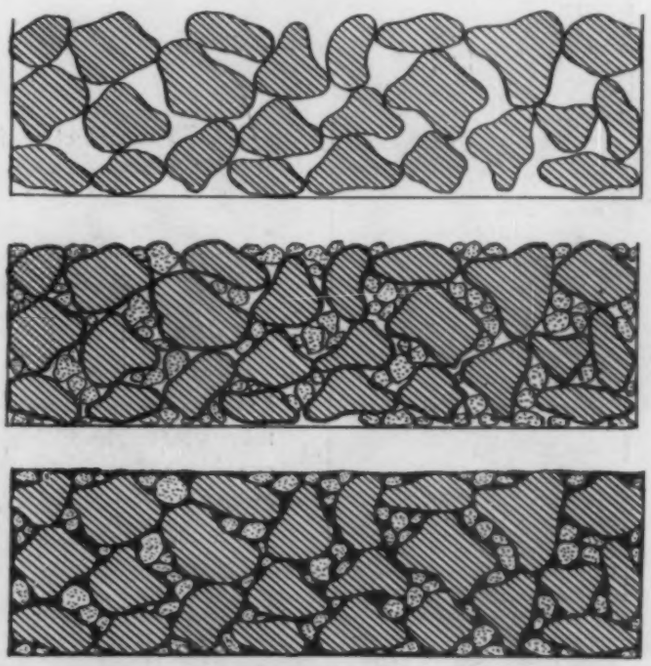
1. The loss of calcium chloride due to chemical reaction with the soil, or base-exchange, is dependent on the chemical composition and the degree of acidity of the soil.

2. The loss due to the washing out effect of rains depends on the type of rains, the permeability of the soil for water and the composition of the soil. The greatest loss from this account would be when a heavy rain might occur immediately following the application of the calcium chloride.

3. The loss due to continued daily maintenance is the most important factor. Sections maintained only immediately after a heavy rain and in addition only when absolutely necessary remain in much better surface condition and far less dust results than on sections receiving daily maintenance. Maintenance at times other than immediately after rains, tends to loosen the surface and dissipate the calcium chloride.

During prolonged dry spells the solution of calcium chloride is brought very close to the surface of the road When rain occurs, the first water absorbed by the road serves to carry this solution down below the road surface. When the surface material has become saturated with water, subsequent rainfall is shed off into the side ditches. Following the rainfall, evaporation of the surface water takes place. As the water in the top layer of the road surface dries it is replaced by the moisture containing calcium chloride, which has been stored below the road surface during the rain. This solution of calcium chloride is brought to the top by the capillarity of the soil material. Evaporation then takes place until a concentration is reached at which the calcium chloride solution will no longer lose water to the air under the existing humidity conditions.

(Continued on page 41)



Gravel alone, shown at the top, lacks cohesion. By adding clay and silt, stability is increased and disintegration reduced. Calcium chloride, by attracting moisture, tends to weld these elements into a hard, compact mass.

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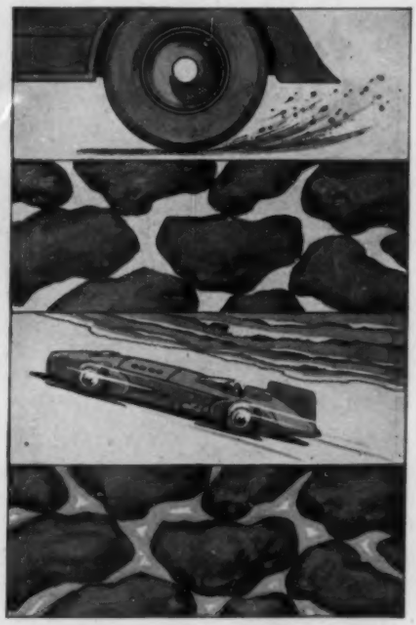
Q. ***Why does an automobile wheel do this to loose, dry particles of road materials?***

A. **Because there is no cohesive element to hold them together. Dry particles of soil, sand, gravel are unstable and slip over one another.**

Q. ***Why is a stretch of tidewater beach the fastest, smoothest, and one of the firmest roadways in the world?***

A. **Because a cohesive moisture-film connects each grain of sand with its neighbor . . . holds them together with a tenacity which exerts tremendous compression effects.**



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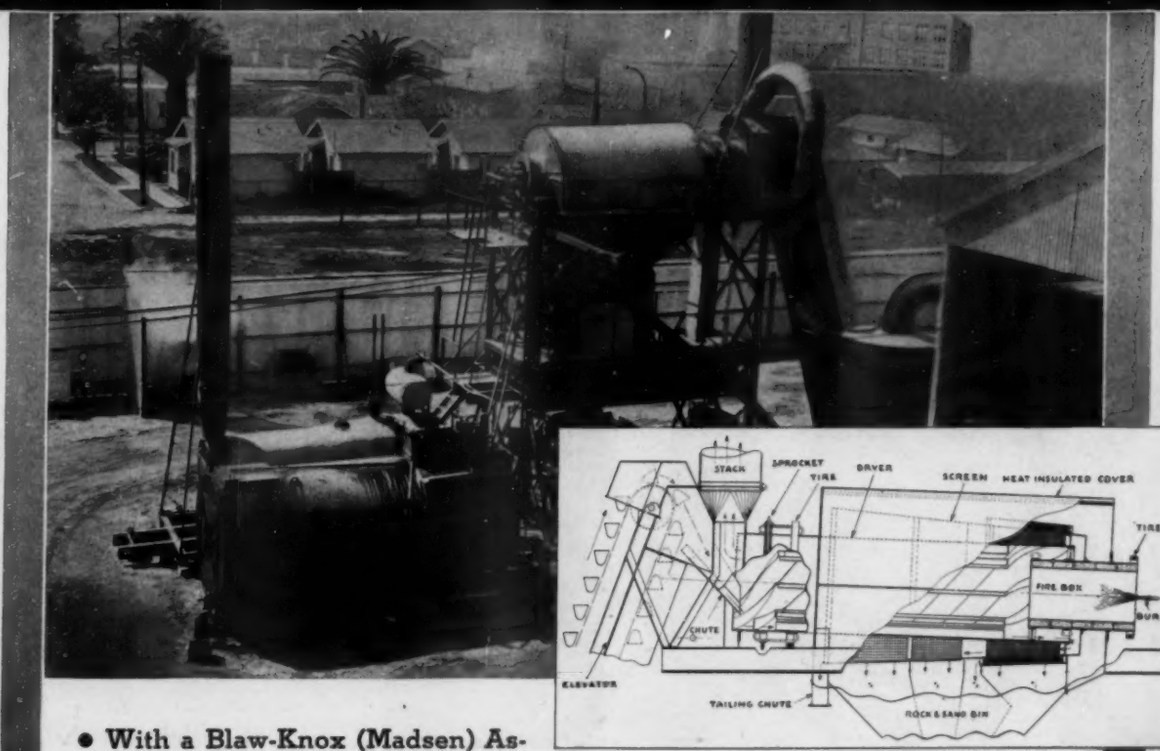

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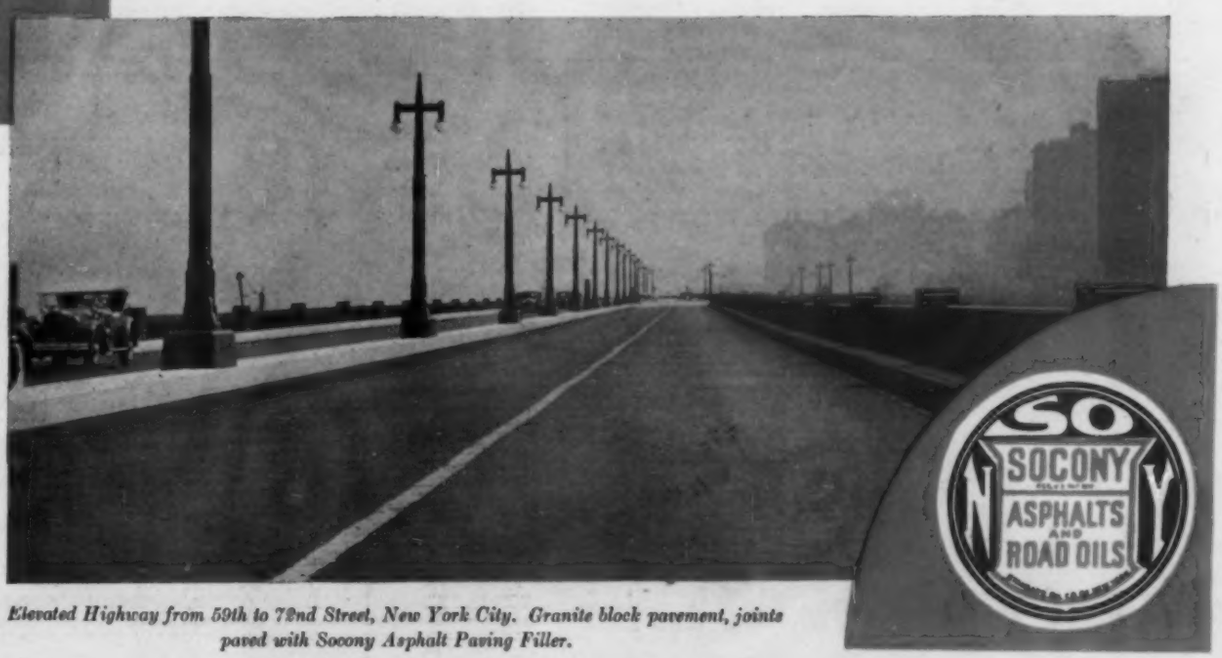

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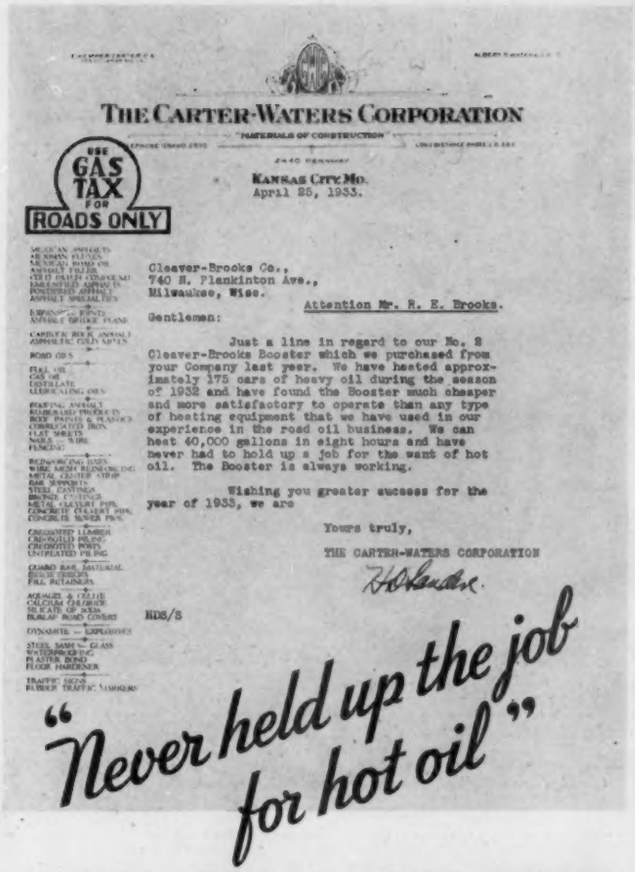

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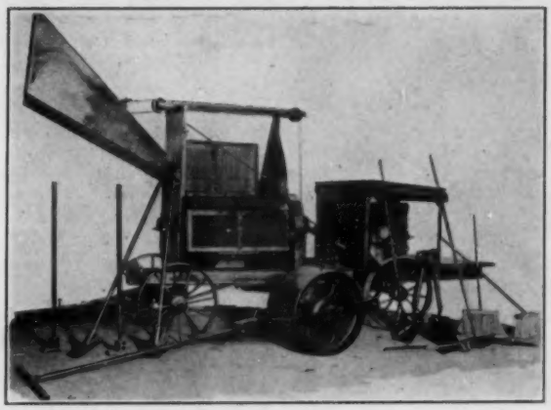

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Development in Tar Surfacing

(Continued from page 28)

cause a variation in the results obtained. Each road surface should be treated according to its needs and not by any fixed rule. When this is done, more uniform and satisfactory results will be obtained.

Hot application tars are being used extensively in conjunction with tar primes and in many cases for retreatment work, where thicker wearing surfaces are desired. This material is particularly well adapted for the seal coat over a tar prime when treating roads where large sized cover material (1¼" and down) and heavy binder are needed to stabilize the treatment. Rolling imbeds the cover material in the tar and old road surface. Dragging is usually omitted but, if desired, a light broom drag may be used to uniformly distribute the cover.

2. Mulch Treatments

Only a few years ago, a gravel road containing loose aggregate on the surface was considered unfit for treatment until the loose material was either bladed or swept to the side of the road. In many cases the loose material was considered unsuitable for use as cover material and was either wasted or used for building up the shoulders. Thus the depth and strength of the road was reduced in proportion to the amount of aggregate removed, as the light surface treatments added little depth to the existing surface.

Today the trend is to utilize the loose aggregate in a gravel, traffic-bound stone or slag road by the use of a mulch treatment or mixed-in-place graded aggregate type surface. The loose material is uniformly spread over the road surface, and, where necessary, new aggregate is added to obtain a minimum loose depth of 1". A 16 to 22 specific viscosity tar at 50° C. is then applied at the rate of approximately 1/3 gallon per square yard, treating one-half the road at a time, or the whole width if the distributor on the work is equipped with proper width extension bars. Immediately after this application the loose aggregate is mixed with the tar by means of a blade grader, pulling the loose material from one-half the road to a point past the center. The exposed surface is primed with the same grade of tar at the rate of approximately 1/3 gallon per square yard. The loose aggregate is then bladed over the primed base and the other half of the exposed surface primed with the same quantity of tar, after which the loose tar treated aggregate is spread uniformly over the entire road surface and thoroughly mixed with a blade grader, maintainer or long base drag.

When the aggregate contains a considerable amount of finely graded material, it is sometimes necessary to apply an additional light application of tar of approximately 1/6 gallon per square yard; after which the treated aggregate is again mixed. If the mix contains too much bitumen it will have a shiny black luster, in which case new aggregate should be worked into the mix until it has a dull black appearance.

Traffic is allowed to use and compact the surface, but if this results in the formation of small ruts, the surface should again be dragged. Rolling, although permissible, is not necessary in this type of construction. After thorough compaction a seal coat of tar is applied and covered with chips or pea gravel. If the same grade of tar is used throughout, the surface should be dragged with a long base drag until the cover material has been spread uniformly over the surface, after which it is compacted by traffic, or if desired, by rolling. If hot tar is used for the seal coat, dragging is omitted and the surface rolled.

Other methods of construction have been used quite successfully for this type, but the method outlined seems superior to the others, due to the fact that every time the aggregate is moved across the road by the blade grader it is mixed with the tar. Another method which has been used quite extensively is to blade the loose material to the sides of the road and then prime the base, blading the loose material back over the primed base preparatory to receiving the application of tar for the mixing operation. In this method the aggregate is moved across the road twice without accomplishing any mixing with the tar, which unnecessarily increases the cost and accomplishes no better results than the method explained.

The mulch treatment has proved a popular type of surfacing because of its low cost and its adaptability for utilizing loose aggregate on a gravel or traffic-bound road. Tar is particularly well adapted for use in mulch treatments, as it mixes readily even with fine aggregate, binding it together into stable, smooth-riding, anti-skid surfaces.

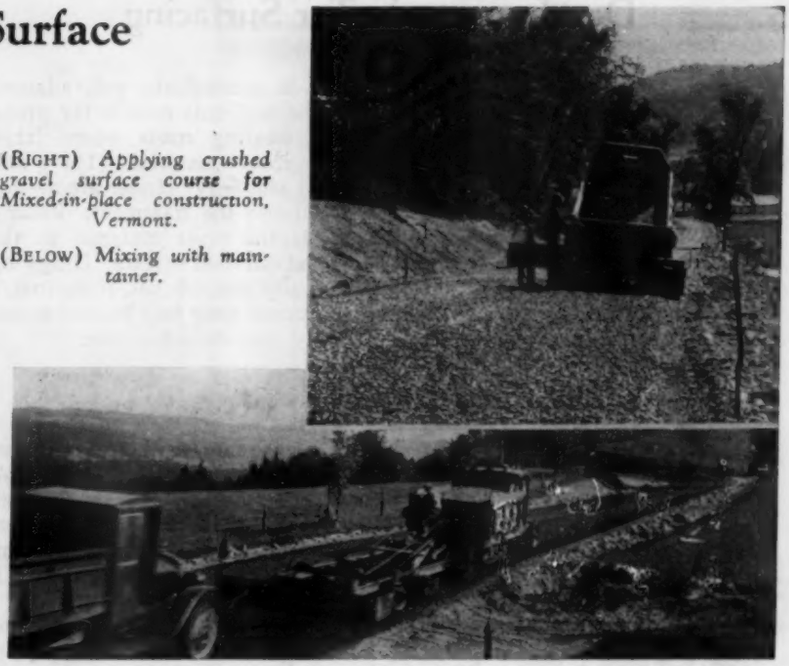
MULCH TREATMENT

(ABOVE) *Half of base primed.*

(RIGHT) *Mixing in Allegan Co., Mich.*

(BELOW) *Windrowing mulch material.*

3. Mixed-in-Place Surface



(RIGHT) *Applying crushed gravel surface course for Mixed-in-place construction, Vermont.*

(BELOW) *Mixing with maintainer.*

The mixed-in-place or road mix, open aggregate type surface, constructed over a suitable base should be used where traffic requires a heavier type surface than obtained by surface treatments. This type of surface has been in use for the last four or five years and has given excellent results. It consists of a layer of crushed aggregate spread to a loose depth of 2½" to 3", to which is applied two applications of heavy cold application tar, which is mixed by blade graders, maintainers or long base drags. The surface is lightly rolled and choked with small chips, and later given a seal coat of tar and chips, dragged and rolled.

To point out the most recent developments in this type of work: The trend has been toward more viscous grades of tar, which mix readily with the aggregate, have greater binding strength and set up more rapidly than the lighter grade. Ordinarily, a tar having a specific viscosity of 26 to 36 at 50°C. is recommended. For work being done in the early spring or late fall a lighter grade of material, having a specific viscosity of 16-22 at 50°C. should be used.

When using cold application tar for this type of construction the seal coat should not be applied too quickly after the mixing operation, otherwise it will penetrate into the mixed surface and tend to soften it, while at the same time an insufficient amount of seal coat material is left on the surface to bind the cover. The result is that the finished surface remains open and is not properly sealed. Better results are obtained by properly choking the mixed surface with chips and allowing traffic to use the road for a period of from two to four weeks or longer. This assures thorough compaction of the surface and closing of the surface voids, with the result that the seal coat remains on the surface and assures a tight, well bonded finished surface.

Where for one reason or another it is not practical to delay the application of the seal coat, very satisfactory results may be obtained by using a cold application tar having a specific viscosity of 16 to 22 or 26 to 36 at 50°C. for the first mixing operation, following with a hot application tar for the second mixing and the seal coat.

The first application of tar penetrates through any dust on the aggregate and slightly cuts back the hot tar after its application, thus assuring thorough mixing with the aggregate. When using hot tar the mixing should be completed the same day the tar is applied. One advantage in this method is that the seal coat may be applied shortly after mixing, choking and rolling.

4. Tar Sand Mix

The tar sand mix is another development in the use of tar. Although its use has been confined to the southern states, there is no reason why this type of surface cannot be used to advantage in any sandy sections where other types of aggregate are not locally available. Usually the surface of the road is plowed or disced or both, to a depth of 6" to 10", depending on the depth of surface decided necessary. Two methods of construction have been used, namely—to pull about 3" to 4" of loose material in windrows along each side of the road, after which the base material is mixed with tar. Upon completion, the material in windrows is spread over the base and mixed with a higher percent of tar. The other method consists of mixing the top course first—to a depth of about 3" or 4" using approximately 1.5 to 2 gallons per square yard in applications of .35 to .5 gallons each. After mixing with disc harrows, the mixture is spread in windrows along the sides of the road. This has the advantage in that it allows the wearing course mix to cure, while the base course is being mixed. In order to give greater stability, the base is mixed slightly leaner, about 3/10 to 4/10 gallons per square yard per 1" of depth. The tar is applied at the rate of about ½ gallon per square yard and mixed with disc harrows. After mixing and spreading, the top course mixture is uniformly bladed over the surface and allowed to cure before rolling. For this type of construction the grade and quantity of tar is dependent upon the gradation of the sand aggregate and the climatic conditions.

A light seal coat of tar covered with small chips is desirable as it produces a tougher surface. This type of construction appears to have great possibilities where there is not available more suitable types of aggregate than sand.

Conclusion

The types of surface described make possible the construction of 18 to 20-foot width pavements at a low cost. When properly constructed. these are unexcelled in riding and non-skid qualities and present safe pavements for modern high speed traffic and transport requirements.

This Paper was presented at the Convention of the Association of Highway Officials of the North Atlantic States, at Atlantic City, N. J., Feb. 16, 1933.

Soil Stabilization in Highway Construction

(Continued from page 31)

From this it can be seen that if maintenance manipulation is carried on while the calcium chloride is near the surface, the material is dissipated; however, if manipulation is carried on during or immediately after a rain, while the calcium chloride solution is some depth below the surface, there will be small loss of calcium chloride.

Tests of the value of calcium chloride for maintenance have also been in progress in several Canadian provinces, particularly in Nova Scotia. During 1929 1,521 miles of gravel roads were treated by this method in this province.

The state of Michigan has used calcium chloride for maintenance very extensively, and has reported the following regarding its use on gravel roads:

> "The ability of a gravel road to resist wear is governed to a marked extent by its moisture content. An excess of moisture impairs the cohesive quality of the binder, and holes and ruts form easily. The absence of capillary moisture is conducive to disintegration, resulting in a cover of loose pebbles which serves as an effective abrasive to accelerate further breaking up of the compacted surface. While this is going on, a heavy loss of material is being sustained, with damage to equipment, growing crops, orchards and fields adjacent to the highways. Proper drainage will reduce excessive amounts of moisture and the use of a deliquescent material will mitigate the difficulties encountered in dry weather."

One value of calcium chloride is its ability to flocculate soil; that is, to cause small particles to group together into larger ones so as to form a more open and permeable soil. This effect is most important in reducing the destructive action caused by freezing. The more open soil does not hold the moisture which, when frozen, creates the expansive forces.

A summary recently offered by the Maintenance Committee of the American Road Builders' Association presents the following outline for the proper use of calcium chloride on a gravel road:

(1) Remove oversize material.
(2) Add to the gravel the constituents it lacks, either sand or clay.
(3) Scarify the surface and thoroughly mix all material added.
(4) Maintain not more than ½-inch to the foot of crown.
(5) Remove all cover and apply calcium chloride.
(6) Blade carefully after each rain and at such other time as the surface of the road demands it.
(7) Patch any holes with the same material as used in the entire surface.
(8) Use heavy equipment for spring work.

Conditions that demand heavier application of calcium chloride are long dry spells, heavy traffic, low clay content, recent heavy resurfacing, no shaded portions, heavy wearing cushion and dead material. Conditions favorable for application are frequent rains, light traffic, heavy clay content and shade.

Adding to the gravel the constituents it lacks, either sand or clay, is one of the most important of the requirements in the outline and has been given a great deal of attention in recent studies as to stabilization of soils. To develop a hard, durable surface one must use the amount and kind of cementing medium which will produce maximum stability. The research work carried on by the Bureau of Public Roads has developed tests which will offer practical information as to the best treatment of soils to obtain maximum stability.

The stability of a soil is dependent on both the cohesion and internal friction which it exhibits. The bind-

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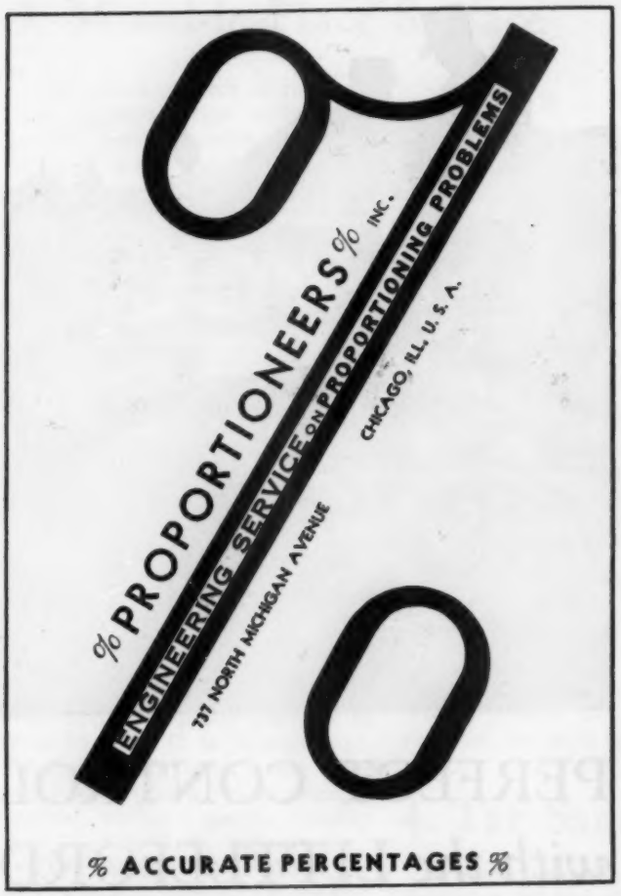
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ON PAGE 51...

On page 51 you will find a special service department for readers of PUBLIC WORKS who want literature covering the very latest developments in equipment and materials used in the construction of public improvements.

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ing power of the clay, or fine material, represents the cohesion necessary for stability while the internal friction is dependent upon the resistance of the soil grains to sliding over each other.

The amount of binder required to furnish stable mixtures depends upon the expansive properties of the binder. Binders which are only slightly expansive may be used in an amount sufficient to fill the pores of the sand almost completely. As the expansive properties of the binder become more and more important, the amount used without danger of unseating the sand grains must of necessity become smaller and smaller. Of two soils whose tendency to shrink or expand are equal, the one having the greater amount of cohesion should be the better binder: of two soils having equal cohesion, that having the less tendency to shrink or expand should be the better binder, since a greater amount of it can be used than of a more expansive soil.

With a satisfactory gradation of sand and gravel particles to form mechanical interlocking and with enough clay to bind the particles together but not sufficient to separate the particles so as to admit of excessive moisture which would make the clay a lubricant rather than a binding medium, an entirely stable combination may be obtained. It is necessary that the clay be moist at all times so as to be expanded sufficiently to press the particles in place and bind them solidly together. This moisture is maintained by the addition of the proper amount of calcium chloride. As stated, the Bureau of Public Roads has developed tests which are simple of performance and offer valuable information as to what treatment a soil requires to obtain maximum stability.

Calcium chloride will save enough material to pay for itself. The proper design of the subgrade material and the use of calcium chloride will permit of a minimum of maintenance with the resulting savings.

When traffic increases to such an extent as to demand a higher type of pavement than the gravel road surface offers, the bearing power of this subgrade may well be considered in the design of any road slab for covering and prove an economical factor. Such stage construction is highly desirable.

Surface Treatment on Caliche Base

Between Muleshoe and Sudan, Tex., relocation reduced the distance from 22 miles to 15 miles. A traffic count indicated 332 vehicles per day using the road. The relocation saved therefore 2,324 car-miles per day or, at four cents a mile, $34,000 per year.

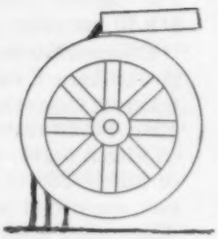
The road was constructed of caliche, put down in two courses, each 4½ inches thick when compacted. The loose material is spread to a depth of 6 inches, wet, rolled and swept to remove the fines. Half a gallon of bituminous material per square yard is then applied hot, and covered with 40 pounds of stone chips.

Excavation and grading amounted to 92,000 square yards. This was taken out by a "Western" Elevator grader and a "Northwest" shovel, loading into Western 1½ yard dump wagons. The caliche pit was opened some three miles from the crushing and screening plant set up alongside the road. This plant consisted of a combination of a Western conveyor, bucket elevator and storage bin, an Austin and a Universal crusher and Simplicity screens. From 50 to 60 trucks were used for hauling.

The total cost per mile of road, including excavation and drainage structures, was about $9,000. The above description is abstracted from an article in the *Earth Mover*.

THE WATER WHEEL

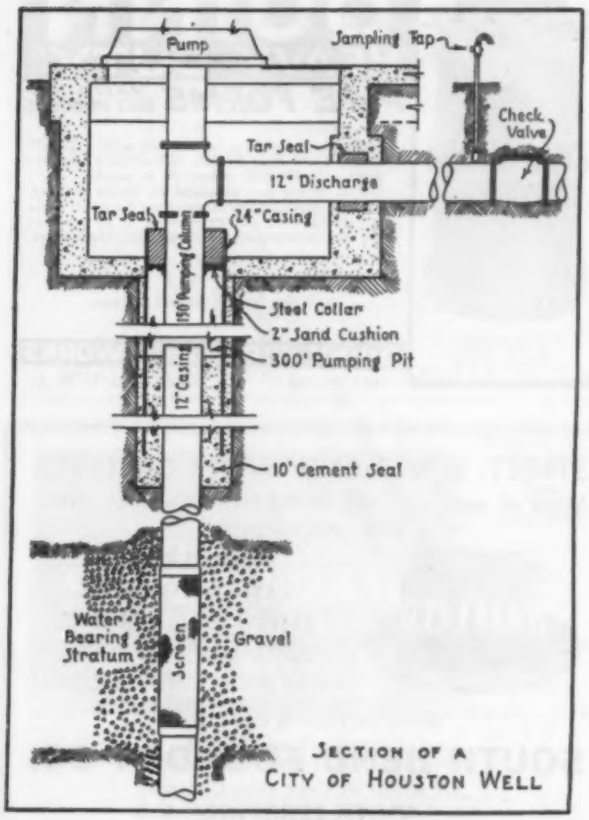
FOLLOWING are the essential features of the important articles of the month having to do with water works design, construction and operation and water purification, arranged in easy reference form and condensed and interpreted. Published every month to include articles appearing during the preceding month.



CAST iron pipe 79 years old was removed in Nashua, N. H., last year.[10] This 10-inch pipe, cast in Nashua, cost $1.50 a foot or about $52.50 a ton. Although the dimensions were about those of present-day Class A pipe, recommended for maximum pressure of 43 pounds, it had withstood a pressure of 50 to occasionally 80 pounds, with only one failure known of. This one was a longitudinal crack, and was repaired 30 years or more ago by "bending a thin piece of metal to the same shape as the outside of the pipe, placing what evidently was white lead between the pipe and this piece of metal and then strapping them securely together." The repair was still holding when the pipe was removed.

Pipe yarns may pollute the water delivered through pipes whose joints it has been used in. Various jute yarns showed from 10 to 600,000 Coli-Aerogenes counts per gram, only tarred jute giving negative results.[12] Mr. Rapp therefore uses in Atlanta, Ga., braided cotton yarn which he considers a sunlight home-grown product which is sanitary and can be kept so, can be used more cheaply (being ready prepared of uniform size), will not protrude into the pipe, insures uniform depth and width of lead space, speeds laying of pipe and reduces joint leakage.

Deep well water is not necessarily safe water. Houston, Tex., took all precautions in sinking its wells[40] as regards drainage, sanitary sewers, pit privies, etc. No well was located closer than 150 ft. to a sanitary sewer. During construction of the wells, toilet faciilties were furnished for workers. Everything used in constructing the wells was kept sterilized. Gravel used in cavities around the screens and mechanical parts placed in the well were chlorinated with a solution of 100 ppm of chlorine. A water-tight concrete pit was built under the floor of the pump house and around the discharge column of the pumps, and a 6 in. tar seal placed between pit floor and column. A special tap for sampling was placed on the pump discharge of each well and samples collected regularly and tested. The water strata used are from 300 ft. to 1850 below the surface. Despite these precautions, of the 25 city wells only 4 have been at all times within the Treasury Dept. standards, indexes as high as 28 and 30 being reached in



SECTION OF A CITY OF HOUSTON WELL

single months, although every well gave zero index a considerable part of the time. Abandoned wells receiving drainage, flood waters, etc., are suggested as a possible cause of pollution. To insure safety, the water is chlorinated. While the water from reservoirs gave average indexes for the year 1931 of from 2.55 to 25.94, chlorinated water from taps has always been within the allowable standard, varying from 2.29 to 0.27; while monthly averages were zero a large part of the time and never exceedd 7.5. "The results obtained from plant taps after chlorination prove beyond a doubt that this method is efficient, economical and very effective."

Acid coagulants in almost every case cause an increase in the sulphate hardness of water in which they are used, according to C. R. Knowles,[33] and in most cases in total incrusting solids, rendering the waters highly corrosive to boilers and hot water systems. Of thirteen treated city water supplies which were analyzed, eight showed an increase in total hardness and eleven in sulphate hardness. He believes that "more serious attention should be given the selection of the chemicals used and methods followed in coagulation in an effort to avoid increasing the hardness."

Concrete lining of the 2:1 slopes of a reservoir for Seattle, Wash., involved some interesting features.[35] The slabs were in general 20 ft. square, 6 in. thick plus a 1-in. mortar topping, the edges resting on ribs 8 in. wide by 4 in. deep set into the earth. No reinforcement was used. The concrete was mixed 1:5 by weight. Before pouring the slabs, the ribs were mopped with asphalt and on this was placed a copper strip crimped at the center and each edge turned up 90° to engage one of the slabs; all joints in the copper strips being soldered. Joints between slabs, 5/8 inch wide, were filled

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with hot asphalt. To use concrete sufficiently plastic to be watertight and still not slide down the slope, a device was used which had first been used on a canal in Yakima Valley. A steel panel 20 ft. long and approximately 4 ft. wide was supported by a steel truss, which in turn rested on headers set on either side of the panel to be concreted. Attached to the truss was a platform upon which the concrete was chuted and from which it was shoveled and tamped under the steel panel. As this space was filled the whole device was raised up the slope, the concrete at the bottom having set sufficiently to maintain itself. Particular attention was paid to obtaining a uniform 3 inch slump for all the slope concrete. The contract price for the lining (let in 1931) was $10.10 per cubic yard.

Construction methods in building Pine Canyon Dam, in Southern California, [5], [44] include several notable features. Gravel is carried from the source to the mixing plant by an aerial tramway 10,200 feet long, carried on fifteen timber structures. There is a horizontal angle of nearly 28° at one point. The longest span is 1650 feet, one end of which is 389 feet higher than the other. There are 7 loaded buckets, each of 32 cu. ft. capacity, and 7 empties in this span at a time, weighing approximately 50,000 pounds, and requiring 150 horsepower to operate at a continuous speed of 500 feet per minute. A loaded bucket reaches the mixer every 25.4 seconds.

To minimize cracking in the concrete of the dam due to contraction following expansion caused by the heat developed in setting, the city of Pasadena furnishes the cement, which, it is specified, must not develop more than 65 calories per gram in seven days, or 80 calories in 28 days. (Ordinary cement develops about 110.)

A softening plant put into service last year at Western Springs, Ill. [89] was designed after experimenting with a model plant operated at a rate of 22 gal. per hr. On the basis of this, Alvord, Burdick & Howson recommended a plan of operation as follows: Aerate; rapid (5 min.) mix of lime and soda ash; slow mix (35 min.); settle 2 hr. and 20 min.; return part of sludge to rapid mixing tank; carbonate 24 min.; filter. Four types of plant were designed and costs estimated: Lime-soda with either one or two units with 140,000 gal. storage for soft water, and a plant without storage; and lime-zeolite. The last had the highest first cost but least operating expenses. The third (without storage) was cheapest in first cost. A 1.5 m.g.d. lime-soda plant, one unit, with storage, gave a total annual cost of $21,090. The third plant gave a total of $20,260, but the former was recommended, presumably because the storage was considered worth more than the $830 a year additional cost.

An apparatus has been designed by F. E. Daniels[47] for the Pennsylvania Health Dept. for collecting river water samples for dissolved oxygen, B.O.D., and alkalinity tests, which prevents contamination of the entering water by the escaping air. It collects four samples simultaneously directly in the test bottles. A brass pail 6" diameter and 8" long is closed by a brass lid held in place on a rubber gasket by two phosphor-bronze clips. Four copper tubes pass through the lid and project down nearly to the bottoms of the four sampling bottles, while a vertical air tube extends from 1" below the lid, through the center of it to about 4" above it. Four regular 135 cc test bottles are placed in the pail. When the pail is sunk, air escapes from the center tube while water enters the bottles through the other four, filling them to overflowing, and continuing to enter until the pail is filled up to the air tube and each bottle filled at least three times.

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c indicates construction article; *n*, note or short article; *t*, technical article.

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46. Elevated Storage at Louisville Cuts Peak-Hour Pumpage, p. 681.

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48. Hazardous Tunneling at Hetch Hetchy, pp. 701-704.

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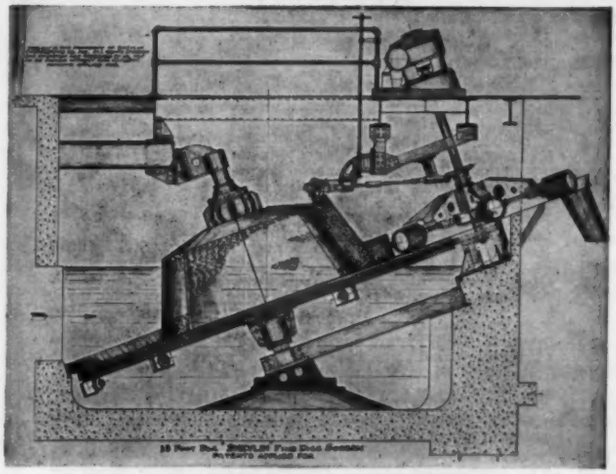

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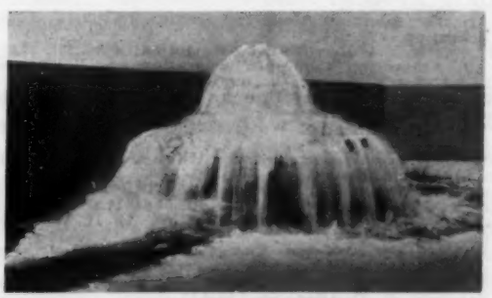

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Brief Notes of New and Improved Equipment

A Review of the Month's Developments in the Industrial Field

Chlorine in ton containers is a real economy for many water and sewage plants, but the ton containers are hard to handle without special equipment. The Lewis-Shepard Co., Watertown Station, Boston, Mass., manufactures the "Jacklift and Cradle Skid Platform System" which is especially suited for easy and flexible handling of such material. Its use allows many plants a considerable saving in the cost of chlorine.

An automatic one-man tractor-scraper has been developed by the Gustav Schaefer Co., Cleveland, Ohio. It is made in four sizes to suit all tractors. It is equipped with direct control; loading, dumping, spreading and leveling are all controlled while the tractor is in motion.

A curing blanket for concrete has been developed by the Western Felt Works, 41st and Ogden Ave., Chicago, Ill. It is said to be much superior to burlap and, while slightly higher in first cost, has a longer life and better curing properties.

The Lufkin Rule Co., Saginaw, Mich. has brought out an "All Stainless" Crescent, No. 5-696. This is marked inches to 16ths for general use; and for engineers to feet, tenths and hundredths on one edge, and in feet, inches and 16ths on the other.

"Jackbits" have been announced by Ingersoll-Rand, 11 Broadway, New York. In these, detachable bits replace the conventional bits forged on the end of drill steels. These provide an economical solution of the drill steel problem for small contractors, quarries and public utility companies, where the services of a sharpener and blacksmith shop are not warranted.

Ingersoll-Rand Jackbit

If you want more information regarding any of the equipment or booklets mentioned on this page, write "Readers' Service Department, Public Works Magazine, 310 East 45th St., New York.

Bituminous distributors of the latest design are described in a newly printed bulletin issued by Austin-Western Road Machinery Co., 400 North Michigan Ave., Chicago, Ill. Ask for Bulletin 1283.

For handling small quantities of liquids efficiently, even under high heads, Roots - Connersville - Wilbraham, Connersville, Ind., has developed a complete new line of turbine pumps. Capacities range from 5 to 300 gallons per minute at heads up to 350 feet.

To anticipate the demand in the sewage field for an automatic ferric chloride proportioning pump, "Proportioneers," of 737 N. Michigan Avenue, Room 302, Chicago, have developed a special unit known as "Ferr-O-Feeder."

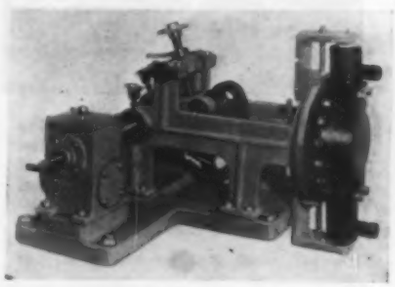
Lufkin All Stainless Crescent

The ferric chloride delivery is handled by a diaphragm type of reagent displacement head, so constructed that all parts which might come in contact with the chloride are of rubber, and containing a pure rubber diaphragm reinforced with six ply whipcord sheeting capable of operating against pressures as high as fifty pounds per square inch. The check valves, also of hard rubber, are built-on to the head in such a manner that they may be readily removed for cleaning or inspection.

The Ferr-O-Feeder may be direct connected through texrope and pulleys to the variable speed line shaft of the sewage pump, and with this arrangement the rate of ferric chloride feed is always maintained proportional to the sludge delivery. If a constant feed is desired, the Ferr-O-Feeder may be driven by an electric motor. In either case the chloride delivery is easily regulated by a convenient stroke adjustment which the operator may manipulate even while the machine is running.

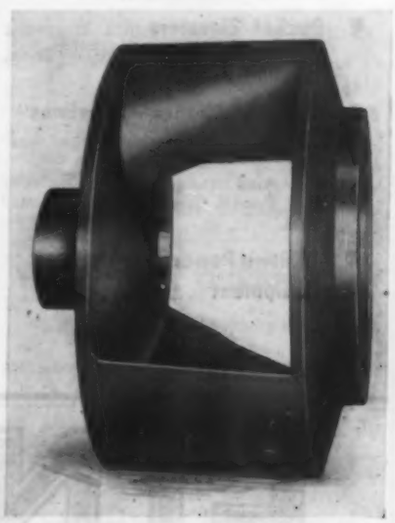
In cases where it is desirable to control the rate of chloride feed directly from the sludge flow, independent of the sewage pump, the double diaphragm type of Tret-O-Unit actuated by the sludge-operated Roto-Flo may be used. This latter method would eliminate any inaccuracy of feed due to varying overall efficiency of the sludge pump.

Ferr-O-Feeder may be obtained in a wide variety of sizes, with deliveries ranging from a maximum of 0.1 gallon to 8 gallons per minute. Interchangeability of various size reagent heads permits adaptation of these units to meet increased plant demands. Adjustment by minute degrees permits the operator to maintain a constant pH concentration at all times.



Ferr-O-Feeder

A non-clogging raw sewage pump, with ball bearings, has been brought out by Buffalo Pumps, Inc., Buffalo, N. Y. It is made in a complete range of sizes and employs a non-clogging rotor. The impeller may be made of cast iron, bronze or other metal. This outfit sells at an unusually low price and is designed for very economical operation.



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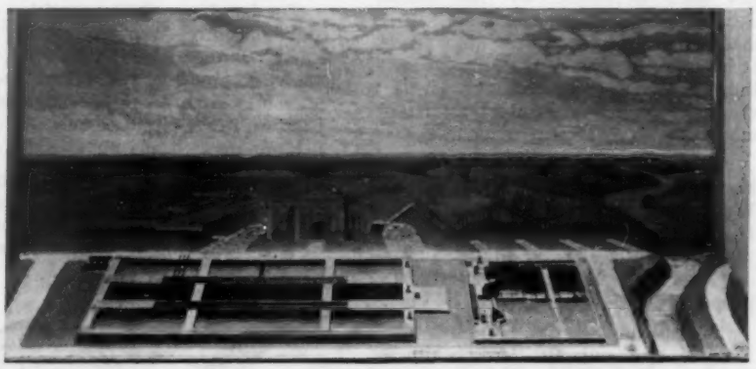

One of 25 dioramas to be shown. This depicts a modern sewage treatment works employing Link-Belt aeration and sludge collection equipment.

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★ *It is a good practice to check this list regularly because descriptions of new bulletins are always being added.*

Construction Materials and Equipment

Asphalt Heaters

8. A 32-page general catalog issued by Littleford Bros., 452 E. Pearl St., Cincinnati, Ohio, describes and illustrates their complete road maintenance line, including tar and asphalt kettles, surface heaters, oil burners, sand dryers, tool boxes, lead and compound furnaces, tool heaters, asphalt tools, joint and crack fillers, squeegee carts, etc.

9. Illustrated manual No. 11 describes "Hotstuff," the master oil burning heater. The only heater with patented elevated melting chamber for Asphalt, Tar and all bitumens used in road and street construction and maintenance, roofing, water proofing, pipe coating, etc. Mohawk Asphalt Heater Co., 94 Weaver St., Schenectady, N. Y.

Asphalt Mixing Plants

10. Precise engineering control of bituminous pavement construction is provided at low initial cost by the new Blaw-Knox (Madsen) portable asphalt mixing plant which is described and illustrated in a new catalog just issued by Blaw-Knox Company, 2019 Farmers Bank Building, Pittsburgh, Pa.

Asphalt Plants

11. A very complete 24 page booklet covering all five sizes and types of Iroquois Asphalt Mixing Plants which are particularly adapted to meet the needs of municipalities and contractors, providing maximum output at minimum cost. Barber Asphalt Co., 1600 Arch St., Philadelphia, Pa.

Bituminus Paving Machines

25. 32 Miles of Bituminous Roads in 256 Machine Hours and similar feats are described in a 16 page booklet (No. BPF) on Bituminous Road Construction with the Barber-Greene Bituminous Paver and Finisher, issued by the Barber-Greene Co., 635 West Park Ave., Aurora, Ill.

Concrete Accelerators

30. "How to Cure Concrete," a forty-seven page manual published by the Dow Chemical Company, Midland, Michigan, treats fully subjects suggested by title.

31. "Curing Concrete Roads with Solvay Calcium Chloride," 30 page booklet. Comprehensive. Contains tables, illustrations, suggestions for testing devices. Covers the subject in considerable detail. Solvay Sales Corp., 61 Broadway, N. Y. C.

35. "A report on Current Practice of using Calcium Chloride for curing Concrete Pavements, Bridges, Culverts and Concrete Products." It includes reports from the Highway Research Board, the Bureau of Public Roads and State Highway Departments. Columbia Products Co., Barberton, Ohio.

Concrete Mixer

44. Concrete Mixers, both Tilting and Non-Tilting types, from 3½s to 84s size. The Jaeger Machine Company, Columbus, Ohio.

Crushers

57. Up-to-date information on Stone Crushers, Stone Spreaders, Unloaders, Drags and other contractors' equipment from the Galion Iron Works & Mfg. Co., E. Jeffry, Mfg. Co., Columbus, Ohio.

Culverts

60. "In diameters up to 10 feet and larger . . ." just issued by the Armco Culvert Mfrs. Assn., tells a good deal about drainage problems and their solution. 32 pages about drainage and multi-plate culverts.

Graders

76. Latest information about Galion Motor Patrol Graders, Road Maintainers and Leaning Wheel Graders with hydraulic control is contained in a new series of illustrated catalogs, Nos. 125, 130, 135 just issued by the Galion Iron Works & Mfg. Co., care of The Jeffrey Mfg. Co., Columbus, Ohio.

77. The new "Speed Patrol," so named because of its ability to speed up maintenance work, is illustrated and described in two new booklets just issued by the Tractor Div., Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Hose and Belting

87. Complete information on rubber hose and belting for all types of contracting and road-building service. The Government Sales Department of the Goodyear Tire & Rubber Co., Inc., Akron, Ohio.

Joint Filler and Line Marker

88. Bulletin No. G-9 issued by Littleford Bros., 452 E. Pearl St. Cincinnati, Ohio, describes and illustrates their new No. 91 Joint Filler which is used to fill horizontal and center joints with hot asphalt. It can be equipped to apply an asphaltic center line as it fills the center joint. This bulletin also describes the Littleford Traffic Line Marker.

Joint Filling Pot

89. A supplement to Bulletin No. E-5 has been issued by Littleford Bros., 452 E. Pearl St., Cincinnati, Ohio, describing their cone-shaped crack filling pot No. 86-B. The chief feature of this pot is that it is springless—there is no mechanism to get out of order. It is used to fill cracks and joints in concrete pavements and interstices in brick or granite block pavements.

Loaders and Unloaders

97. Portable Loaders and Unloaders. Folders: Nos. 1248, 1298 and 1074 cover Belt Conveyors with channel iron and truss types of framework; No. 1076, Portable Bucket elevators for different classes of work; and No. 1256, the "Grizzly" Crawler Loader for heavy work and large capacities. Link-Belt Company, Philadelphia

100. Materials Handling and Positive Power Transmission Equipment, giving technical data, list prices and illustrations of this machinery. Link-Belt Co., Chicago, Ill. General Catalog No. 500.

Motor Trucks

105. A new line of heavy duty motor trucks and tractors for dump and commercial hauling is described in literature recently issued by the Sterling Motor Truck Co., Milwaukee, Wis.

Paving Materials

109. A 36-page booklet with 66 illustrations has just been issued by the Barrett Co., giving full information regarding the making, laying and maintaining of "Tarvia-lithic," the ready-to-lay pavement.

111. "Tarvia Double Seal Pavements." Shows, step by step, the construction of a Tarvia pavement. 24 pages. The Barrett Company, 40 Rector Street, New York.

112. Complete directions for surface Cut Back Asphalt are contained in a 36 treatment and bituminous surfacing with page data book. Standard Oil Co. of Indiana, 910 So. Michigan Ave., Chicago, Ill.

113. Complete and detailed specification sheets on Road Oil and Penetration Asphalts, furnished on request by the MacMillan Petroleum Corp., El Dorado, Arkansas.

114. Complete information concerning Alabama Asphaltic Limestone will be sent promptly on request to the Alabama Asphaltic Limestone Co., Liberty National Bldg., Birmingham, Ala.

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Road Machinery

127. "Road Machinery Illustrated." New illustrated bulletins on the motor rollers, three-wheel and tandem rollers, motor graders powered by Caterpillar, Twin City, Cletrac, McCormick-Deering and Fordson tractors, and straight and leaning wheel graders. Galion Iron Works & Mfg. Co., Galion, O.

Rollers

132. A 32-page book in four colors featuring a complete line of road rollers. 8¾ x 11, leatherette cover, numerous action pictures. Buffalo-Springfield Roller Co. of Springfield, Ohio.

133. 20-page pocket size booklet showing all types of Buffalo-Springfield motor rollers and scarifiers and their uses.

134. "The Chief," a six cylinder roller of advanced design and construction is fully described in an illustrated catalog just issued by the Galion Iron Works & Mfg. Co., care of The Jeffrey Mfg. Co., Columbus, Ohio. Gives complete details of the very latest development by this company.

Sand and Gravel Washing Plants

140. Seventy-page catalog giving complete information regarding Sand and Gravel Washing Plants, stationary and portable. Those interested in such equipment should have a copy. Link-Belt Co., Chicago, Ill.

Shovels, Cranes and Excavators

144. Complete information including operating ranges of General Excavators is given in Bulletin No. 3210 recently prepared by The General Excavator Co., 365 Rose St., Marion, Ohio.

146. Link-Belt Co., Chicago, Ill., has issued Book No. 1095, which describes and illustrates their complete line of Gasoline, Electric, or Diesel operated shovels, cranes and draglines. 910 S. Mich. Ave.

Steel Posts

160. Steel Posts for highway guard rails, fences and other purposes. Catalog and data book. Sweet's Steel Company, Williamsport Pa.

Surveying Instruments

163. A complete catalog and instruction book pertaining to the "Sterling" transits and levels are described and illustrated in a 64-page booklet. Warren-Knight Co., 136 No. 12th St., Philadelphia, Pa.

Tires, Truck and Tractor

165. Speed and economy in use of solid, cushion and pneumatic tires and tubes for trucks, cars, tractors, graders and other road machinery. Government Sales Department of the Goodyear Tire & Rubber Company, Inc., Akron, Ohio.

Tool Boxes

167. Bulletin No. G-6 issued by Littleford Bros. 452 E. Pearl St., Cincinnati, Ohio, describes and illustrates the Han-DeeBox, a portable tool box of all-steel construction. This tool box is equipped with a special locking device that locks both covers at the same time. No padlocks are used. Littleford trailers, lead melting furnaces, and "Hot Dope" Kettles for pipe coating are also described in this bulletin.

Tractors

170. Everything you want to know about the Model L Allis-Chalmers Tractor is contained in a new 30 page illustrated booklet issued by the Tractor Div., Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Road and Street Maintenance

Asphalt Heaters

8. A 32-page general catalog issued by Littleford Bros., 452 E. Pearl St., Cincinnati, Ohio, describes and illustrates their complete road maintenance line, including tar and asphalt kettles, surface heaters, oil burners, sand dryers, tool boxes, lead and compound furnaces, tool heaters, asphalt tools, joint and crack fillers, squeegee carts, etc.

Asphalt Mixing Plants

10. Precise engineering control of bituminous pavement construction is provided at low initial cost by the new Blaw-Knox (Madsen) portable asphalt mixing plant which is described and illustrated in a new catalog just issued by Blaw-Knox Company, 2019 Farmers Bank Building, Pittsburgh, Pa.

200. For general construction and maintenance, the Original Improved "Hotstuff" Asphalt Heater, an economical oil burning heater. Mohawk Asphalt Heater Co., 56 Weaver St., Schenectady, N. Y.

201. "Heating Bituminous Materials" is a new booklet dealing with the problems involved in heating bituminous materials shipped in railroad tank cars and contains full data regarding the Cleaver-Brooks equipment for meeting all heating requirements. Published by Cleaver-Brooks Co., 740 No. Plankinton Ave., Milwaukee, Wis.

Distributors

206. Kinney distributors of from 600 to 1,700 gallon tank capacity with heating system and the Kinney jacketed pump having a capacity of over 400 gallons per minute are described in a new catalog just published by the Kinney Mfg. Co., 3529 Washington St., Boston, Mass.

208. "Important Message for Those Road Builders Who Want More for Their Money," a new folder on low-cost roads, and three illustrated bulletins covering their line of asphalt, tar and oil distributors will be sent promptly by E. D. Etnyre & Co., Oregon, Ill.

Dust Control

210. "How to Maintain Roads," by the Dow Chemical Company, Midland, Michigan, is a manual dealing thoroughly with dust control, road building and maintenance.

211. "Dust Control," a concise, handy pocket reference on control of dust by use of 3C Calcium Chloride. Illustrated. Issued by the Columbia Products Company, Barberton, Ohio.

212. "Wyandotte Calcium Chloride Prevents Dust the Natural Way,"—a publication, fully illustrated, treating on Dust Control, economical road maintenance and methods of application, issued by the Michigan Alkali Company, 10 E. 40th St., New York City.

Dust Laying

213. Full information regarding the use of Solvay Calcium Chloride for effectively laying dust. The booklet, "Solvay Calcium Chloride, a Natural Dust Layer," 24 pages, 5½x8, covers application, economies, etc. Sent without cost. Solvay Sales Corporation, New York.

Emulsion Sprayers

214.—A complete line of emulsion sprayers is described in Bulletin No. G-5 recently issued by Littleford Bros., 452 E. Pearl St., Cincinnati, Ohio. Littleford Emulsion Sprayers will spray any type of asphalt emulsion used for penetration patch work or curing concrete. They are also used to spray silicate of soda and weed exterminators.

Surface Heaters

220. The "Hotstuff" three in one, combination Tool, Asphalt and Surface heater is described and its use illustrated in Bulletin 16. Mohawk Asphalt Heater Co., 56 Weaver St., Schenectady, N. Y.

Road and Paving Materials

Bituminous Materials

113. Complete and detailed specification sheets on Road Oil and Penetration Asphalts, furnished on request by the Macmillan Petroleum Corp., El Dorado, Arkansas.

225. "Enduring Pavements and the Evidence." Everyone should have this data book on the use of lake asphalts. Contains 33 illustrations and list of streets and highways in this country paved with Natural Lake Asphalts. Gives yardages and days laid. Issued by the Barber Asphalt Co., 600 Arch St., Philadelphia, Pa.

226. Full details concerning the uses and advantages of Lincolnite Pulverized Petroleum Asphalt, Linco Road Oils, Cutback Asphalt Cement and Penetration Asphalt Cements will be sent free on request by Lincoln Oil Refining Co., Box 251, Robinson, Ill.

227. "Asphalt for Every Purpose a 44-page illustrated booklet describing Stanolind Asphalt products. Standard Oil Co. of Indiana, 910 So. Michigan Ave., Chicago, Ill.

228. A new booklet has just been issued by The Barrett Co., 40 Rector St., New York, describing and illustrating the uses of each grade of Tarvia and Tarvialithic. 32 excellent illustrations.

229. A new series of concise and authoritative manuals of construction covering the latest developments in road-mix and surface treatment types as well as the standard asphalt pavements. These contain the best that has been developed by study, research and practical application in all types. Manual 1—Road-Mix Types, is now ready for distribution. The Asphalt Institute, 801 Second Ave., New York, N. Y.

229A. Surface Treatment Types, Asphalt Road Construction Manual No. 2. Full details on surface treatments. 14 chapters. 128 pages. The second of those tremendously valuable and handy little manuals put out by the Asphalt Institute, 801 Second Avenue, N. Y. Sent on request.

Brick, Paving

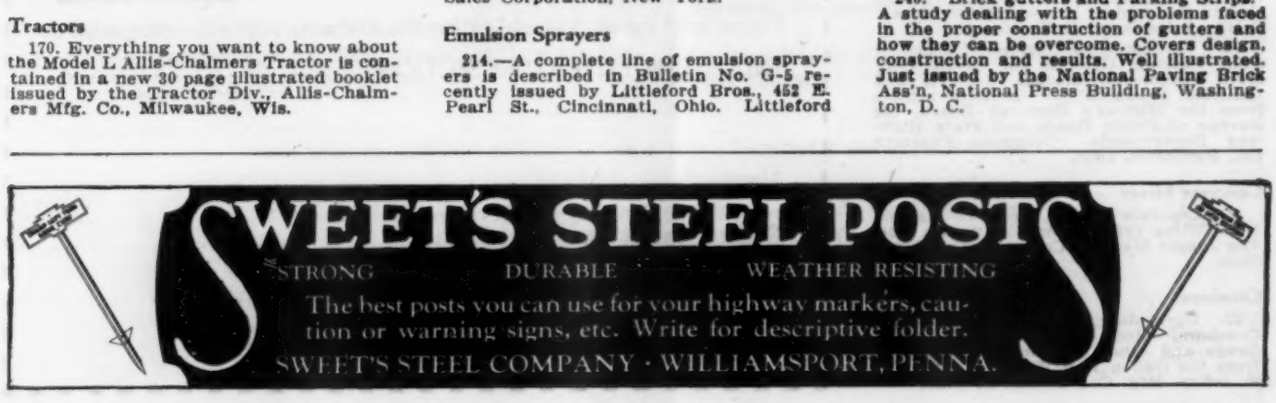
230. Full information and data regarding the use of vitrified brick as a paving material, cost, method of laying, life, etc. National Paving Brick Manufacturers' Association, National Press Building, Washington, D. C.

Concrete Curing

235. "How to Cure Concrete," is a manual of instruction on the curing of concrete pavements. 47 pages. The Dow Chemical Company, Midland, Mich.

Gutters

240. "Brick gutters and Parking Strips." A study dealing with the problems faced in the proper construction of gutters and how they can be overcome. Covers design, construction and results. Well illustrated. Just issued by the National Paving Brick Ass'n, National Press Building, Washington, D. C.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News of the Engineering World

Personal Items—Books—Recent Developments

With the Engineers

Fuller & Everett, civil engineers, have moved from 22 East 40th St., New York, to the 25th floor of the New York Trust Building.

The engineering business of Daniel W. Mead and Charles V. Seastone is now being conducted by their former associates, Harold W. Mead, Clayton N. Ward and Henry J. Hunt, under the name of Mead, Ward and Hunt, with Mr. Ward as chief engineer. Mr. Daniel W. Mead and Mr. Seastone will continue in an advisory capacity.

The appropriation for Stream Pollution Investigation of the U. S. Public Health Service has been reduced more than fifty per cent, and, as a result, all the junior scientific personnel will be dismissed.

John P. Harris, manager of the Chicago office of the Industrial Chemical Sales Co., N. Y., has been elected president of the American Oil Chemists' Society.

A letter has been received from I. W. Mendelsohn, formerly editor of the *Waterwheel*, who is making a trip around the world. He reports that he has seen and studied many foreign water and sewage plants. Upon his return in July, Mr. Mendelsohn will prepare a series of articles for PUBLIC WORKS covering his studies.

Booklets, Bulletins and Catalogs

"The Welding of Enduro Stainless Alloys" is treated very comprehensively in a new booklet published by the Republic Steel Corporation, Central Alloy Division, Massillon, O. Among the subjects treated are: Electric arc welding, gas welding, spot and projection welding, seam welding, and flash welding.

"Economics of Highway Improvement," published by the Portland Cement Association, 33 West Grand Avenue, Chicago, Ill., ought to be in the library of every engineer. The material is so prepared that highway engineers can apply it to their own traffic, construction and maintenance problems. The work of the Highway Research Board is summarized; and the essential findings of the Committee on the Economics of Highway Improvement are here assembled for the first time under one cover, and applied to a practical solution of road building problems.

"Cement-Bound Macadam" is discussed and described in a 16-page illustrated booklet put out by the Portland Cement Association, Chicago, Ill. Recommended designs and specifications are included, along with much other data.

The Koehring 601 shovel, crane, dragline and pullshovel are described in a new booklet which is filled with technical information for the man who needs a 1¼-1½ yard machine of modern design.

"Long-Life Pavements," "True Economy" and "Barber Emulsified Asphalts" are the titles of three publications recently issued by the Barber Asphalt Co., Philadelphia, Pa.

Recent Books in Brief

Transition Zoning: By Professor Arthur C. Comey. $2.50. The Harvard University Press. This book contains new and fresh information regarding the development of cities, and should be of value to municipal officials, real estate men and city planners.

Earth Dam Projects: By J. D. Justin. John Wiley & Sons. $5. Covers the field in a most interesting and valuable form. One-half the material is devoted to a study of earth dam failures.

Water Purification Control: By Edward S. Hopkins, principal sanitary chemist, Baltimore Bureau of Water Supply. Williams & Wilkins Co. $1.75. Among the subjects covered are mixing basins; sedimentation; filtration; disinfection; tastes and odors; corrective treatment; and plant control.

Accounting Manual for Small Cities: By Carl H. Chatters, Municipal Finance Officers' Assn. $1. This text refers particularly to municipalities of 25,000 population and less. It is a most practical and valuable manual.

From the Manufacturers

The Central Foundry Co. Chicago Sales Office of the Universal Pipe Division is now located at 1629 Wellington St., corner of Paulina St.

Neil C. Hurley has been elected president of the Chicago Pneumatic Tool Co., Chicago, Ill., succeeding Ralph S. Cooper, who becomes vice president in charge of Eastern operations, with headquarters in New York. Frank B. Hamerly and Gordon H. McCrae were also elected vice presidents in charge of the factory at Aurora, Ill., and of foreign business, respectively.

The New York office of the Morris Machine Works, Baldwinsville, N. Y., has been moved to 254 West 31st St.

Raymond F. Garcia has been appointed General Manager of Sales, Universal Pipe Division of the Central Foundry Co., succeeding Leonard W. Saine, who has resigned. Mr. Garcia will make his headquarters at the general offices of the Company, 420 Lexington Avenue, New York. Mr. Saine has organized his own business in Orlando, Fla.

The Smith Booth Usher Company in Los Angeles, R. W. Simpson in Des Moines, Iowa, and The Ray Corson-Elkins Company in Denver, Colo., have been appointed distributors for Littleford Bros., Cincinnati, O.

Thirteen Diesel-powered models have been announced powered by Sterling Motor Truck Co., and the first regular production models are now under construction at the Sterling factory at Milwaukee. A number of the larger units are already sold and will go into immediate service. The new models range in capacity from 4 tons upwards and are designed for all types of heavy duty service from roadbuilding and excavation work to cross-country fast freight transportation. Severe tests have determined that fuel costs can be reduced from 60 to 75% by the use of Diesel engines. In addition, other economies are also effected in the use of Diesel over the conventional type of gasoline engine through the elimination of the electrical equipment, as the Diesel engine gets its ignition from compressed air instead of the regular spark plug system. In addition, this new type of engine develops greater lugging power than comparable gasoline motors and fire hazards are eliminated.

A new tandem axle machinery trailer has been developed by C. R. Jahn Co., Builders Building, Chicago, Ill. It is 8 feet wide, fully reversible, and is built in capacities up to 36 tons. Can be towed from either end. The loading platform is flat, and can be loaded from either end or the side. It is mounted on pneumatic tires. The design complies with axle load limits and trailer width regulations of most states.

The Vulcalock Valve, made by the B. F. Goodrich Co., Akron, O., is a rubber-lined valve suitable for handling corrosive and abrasive fluids under high pressure, pulsating pressure, throttling or suction.

With present low excavating prices in mind, the Harnischfeger Corporation, Milwaukee, Wisc., has developed a line of excavators with "Split second control," to meet the requirements of greater yardage at lower cost. One of the important developments is a speeding up of the digging cycle.

A new model street and highway maintenance machine has been announced by the White Manufacturing Co., Elkhart, Ind. This machine which is designed to meet the great present need for better maintenance equipment, will mix any formula for base binder or top—sheet asphalt, cut-back, oleum spirit, etc.—to match any old pavement type, or will furnish a fine mix for resurfacing hard pavements. It is especially adapted for repair work and resurfacing brick and concrete, as well as for all types of bituminous work. Its capacity is 25 tons a day of hot mix or 40 tons of low or medium temperature mix.

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Elrod, Henry E.	49	National Water Main Cleaning Co.	4	Wiedeman & Singleton	50

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260. No interruption to traffic, and substantial savings in construction costs are the main advantages secured by using the Armco jacking method to install conduits, drainage openings, and passageways under streets, highways and railroads. "The Armco Jacking Method," describing this modern means of construction and its many applications, will be sent upon request, by Armco Culvert Mfrs. Association, Middletown, Ohio. Ask for Catalog No. 7.

Maintenance Materials and Methods

270. "How to Maintain Roads," by the Dow Chemical Company, Midland, Michigan, is a manual dealing thoroughly with road building, maintenance and dust control.

275. "Tarvia-K. P. for Cold Patching." An instructive booklet illustrating and describing each step in patching a road with "Tarvia-K. P." 16 pages, illustrated, 3½x9. The Barrett Company, New York.

276. "Road Maintenance with Tarvia." A 56-page illustrated booklet of value to every road man. Shows how almost every type of road and pavement can be repaired and maintained with Tarvia. The Barrett Company, New York.

Snow Removal

Snow Fences

345. "Standard and Heavy Duty Reversible Blade Snow Plows for Motor Trucks," a new bulletin just published by the Monarch Mfg. Co., East Front St., Wilmington, Del. Illustrated. Contains complete descriptions and specifications.

349. "The Answer to the Snow Removal Problem." It gives full details of the Frink type S snow plow for trucks. Carl Frink, Mfr. of Clayton, N. Y.

359. Galion Iron Works and Mfg. Co., Galion, Ohio. Details, prices and catalogs of their snow plows adaptable to any make of truck.

Sanitary Engineering

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381. Proportioneer's Inc., 737 N. Michigan Ave., Chicago, describe in an 8 page folder their mechanical devices for controlling accurately and automatically the flow of fluids used for treatment of water supply and sewage. Ferr-O-Feeder—diaphragm pump for Ferric-Chloride or other corrosive fluids; Chlor-O-Feeder for Hypochlorate solutions. Write for a free copy.

Ferric Chloride

382. Full information concerning the experiences in the use of ferric chloride for use in sludge conditioning and in coagulating sewage will be sent promptly by Innis, Speiden & Co., 117 Liberty St., New York, N. Y.

383. Loughlin Clarifying Tanks for the more complete removal of suspended solids from sewage and industrial wastes at lower cost are described in a new bulletin just issued by Filtration Equipment Co., 350 Madison Ave., New York, N. Y.

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402. Full details concerning No. 1 Korite for sealing sewer pipe joints so that they will be permanently tight. Standard Oil Co. of Indiana, 910 So Michigan Ave., Chicago, Ill.

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Pumping Engines

413. "When Power Is Down," gives recommendations of models for standby services for all power requirements. Sterling Engine Company, Buffalo, N. Y.

Screens, Sewage

417. The simple, automatic, Loughlin self-cleaning traveling screen is fully described in a new bulletin just issued by Filtration Equipment Co., 350 Madison Ave., New York, N. Y.

418. Sewage screens (Tark, Brunotte, and Straightline) for fine and coarse sewage; Straightline Collectors for Settling Tanks (Sludge, Scum and Grit), and Mechanical Aerators for activated sludge plants. Link Belt Company, 910 So. Michigan Ave., Chicago, Ill. Book 642.

419. An illustrated booklet showing installations, and complete details regarding the 19 exclusive improvements which are featured in Shevlin Fine Disc Screens will be sent promptly by the Shevlin Engineering Co., Inc., 227 Fulton St., New York, N. Y.

420. A useful new bulletin for all those interested in sewage disposal, describing some of their proven equipment such as self-cleaning bar screens, grit conveyors, sludge collectors and shredders, has just been issued by the Jeffrey Mfg. Co., Columbus, Ohio. Includes diagrams and many illustrations.

Screens

424. Water Screen Book No. 1252, describes water screens and gives complete technical information about them. Link-Belt Co., Chicago, Ill.

Sludge Bed Glass Covers

426. Sludge Bed Glass Covers—"Super-Frame" Hitchings & Co., Main Office, Elizabeth, New Jersey. Offer A. I. A. File 101SB, describing glass covers for sludge and sprinkler beds; details, specifications and cost data.

Sludge Conditioning

381. Full information concerning the experiences in the use of ferric chloride for use in sludge conditioning and in coagulating sewage will be sent promptly by Innis, Speiden & Co., 117 Liberty St., New York, N. Y.

Treatment

430. Separate bulletins showing their many lines of sewage treatment equipment will be sent promptly by The Pacific Flush Tank Co., Chicago and New York. The latest is No. 110 describing tray clarifiers.

433. Collectors and concentrators for modern sewage treatment plants, recent installations, and full data on aerators, and screens. Link Belt Co., 910 So. Michigan Ave., Chicago, Ill. and Philadelphia.

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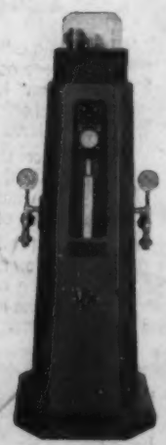

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